The Journal of Bone and Joint Surgery

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association

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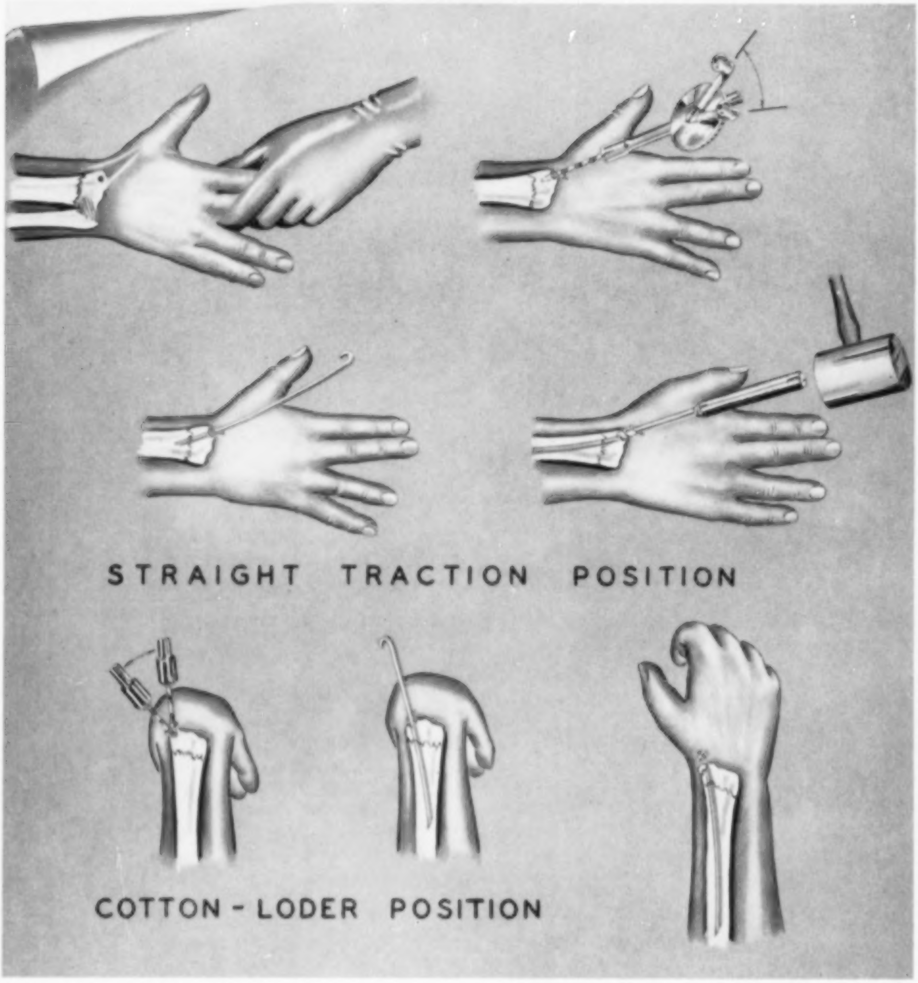
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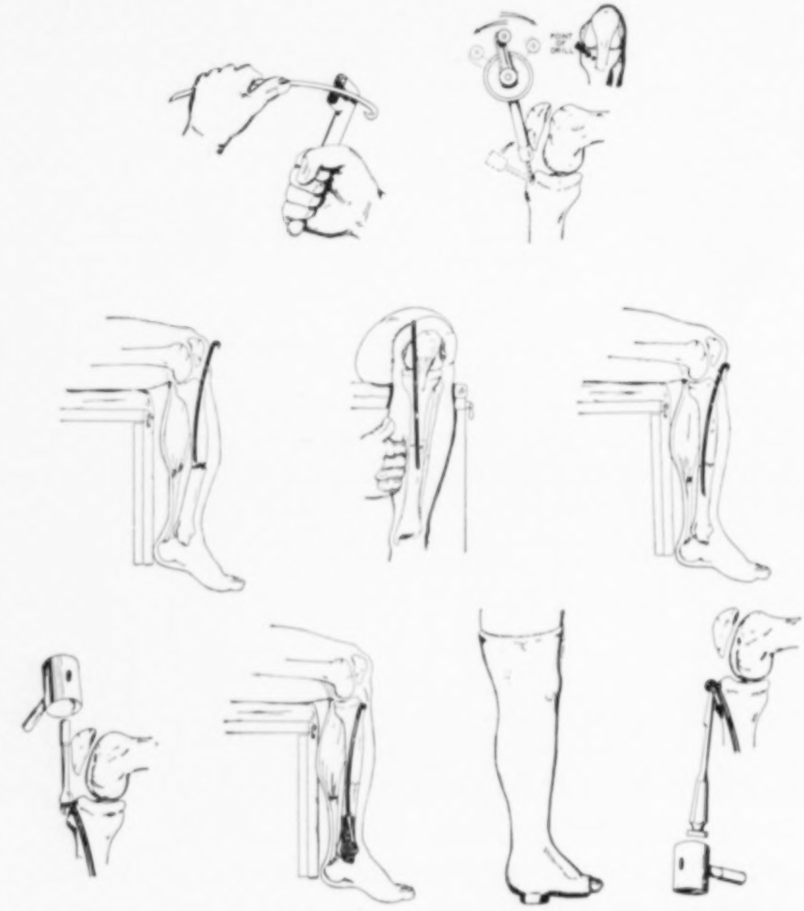

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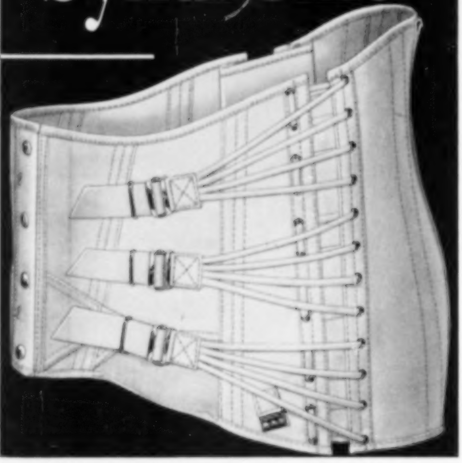

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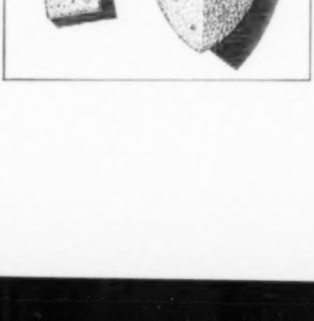

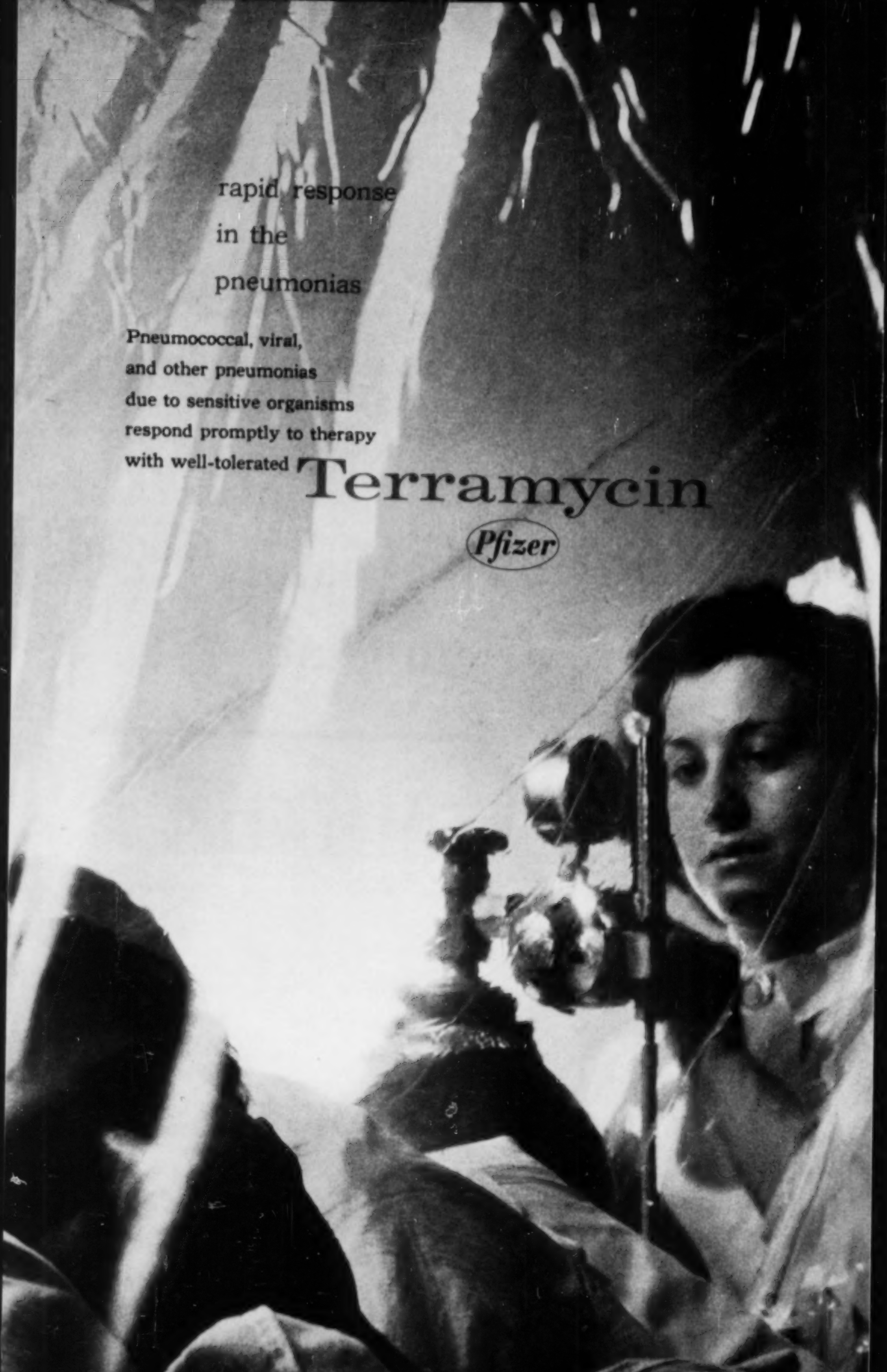

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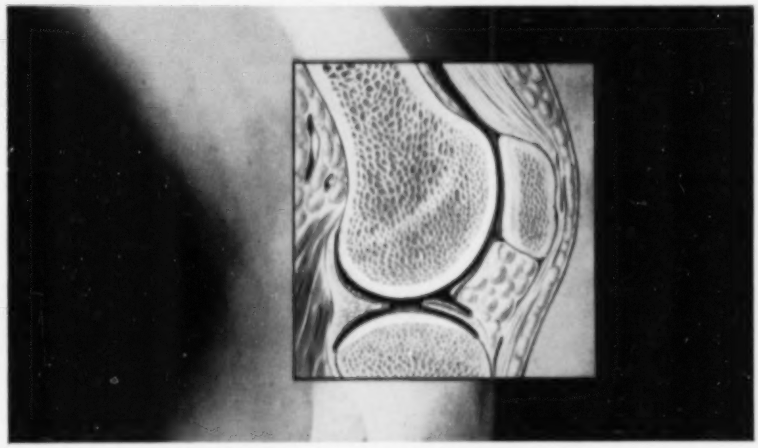

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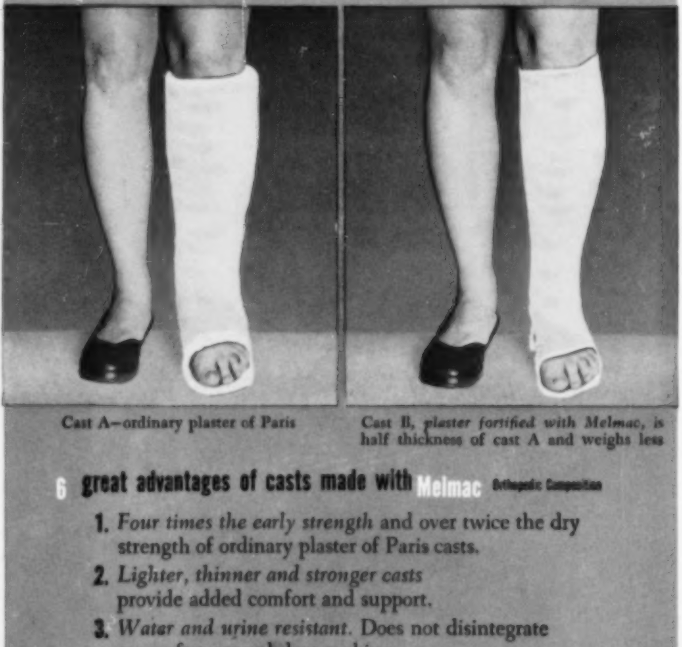

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2. M. C. Cobey, M.D., F.A.C.S., Professor of Orthopedic Surgery, Georgetown University and Senior Attending Orthopedic Surgeon, Children's Hospital, Washington, D.C., The American Surgeon, Vol. XVIII, No. 4, April, 1952, pp. 413, 415.
3. M. C. Cobey, M.D., F.A.C.S., Washington, D.C., private communication.

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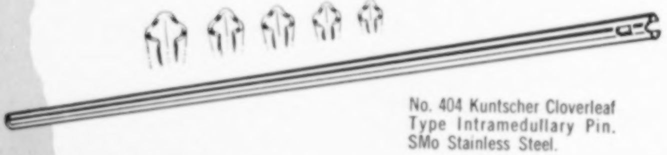

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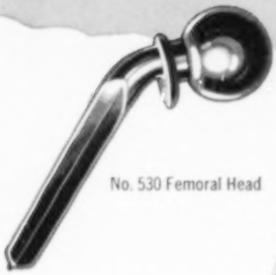

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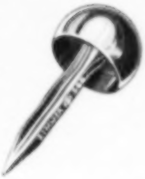

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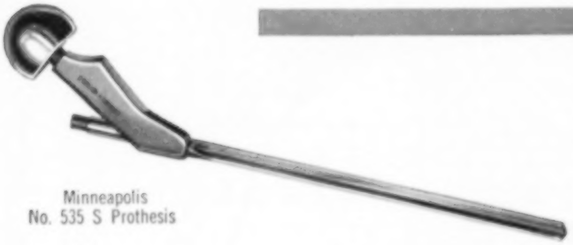

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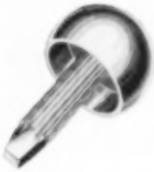

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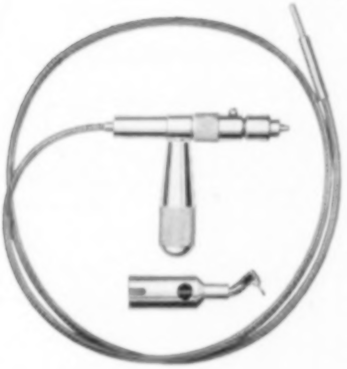

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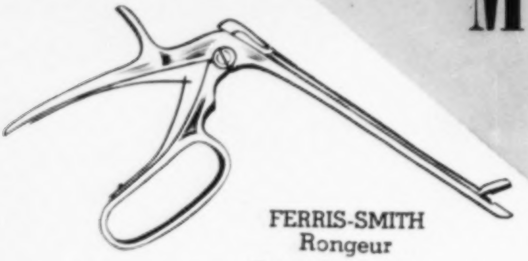

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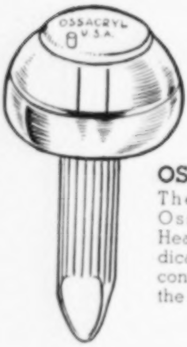

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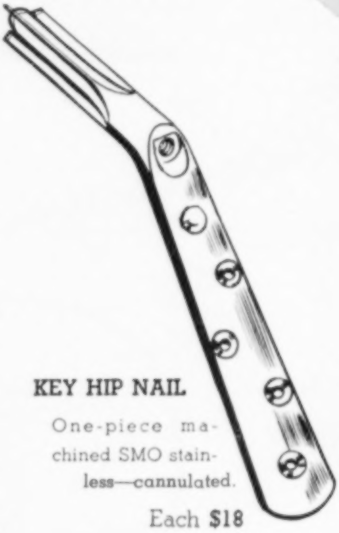

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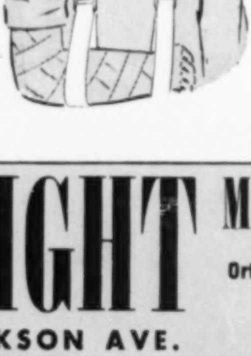

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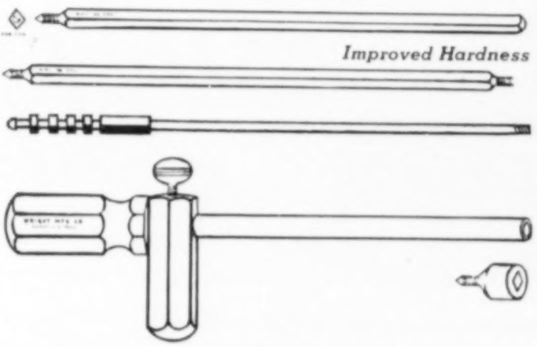

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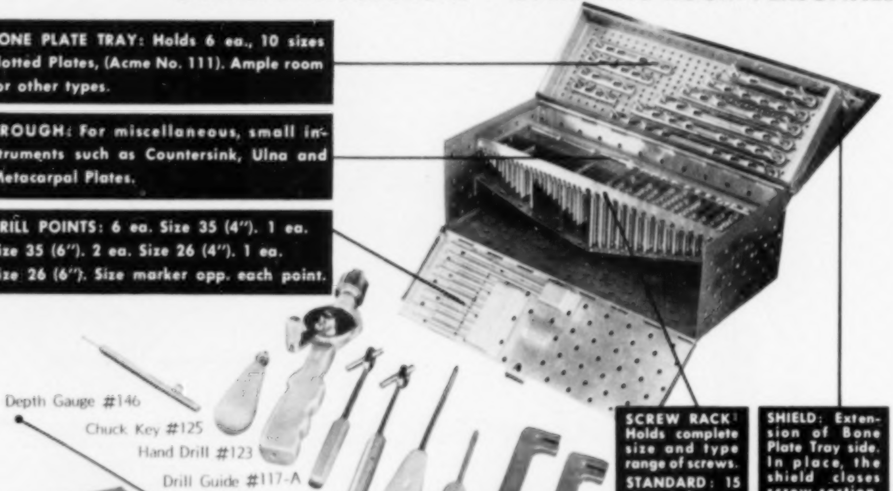

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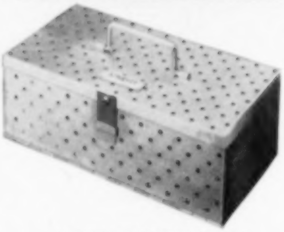

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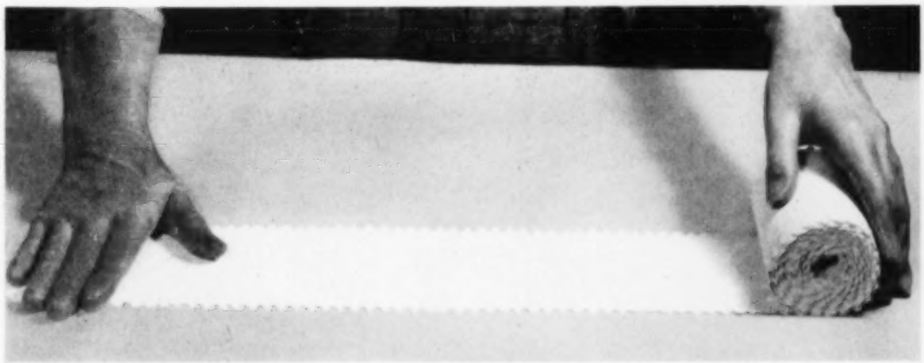
PLASTER CASTS THAT ARE HARD, LIGHTWEIGHT, ECONOMICAL AND EASILY APPLIED



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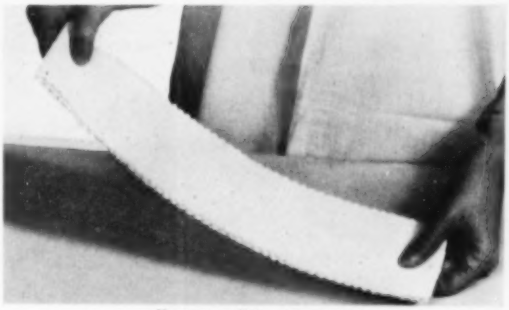

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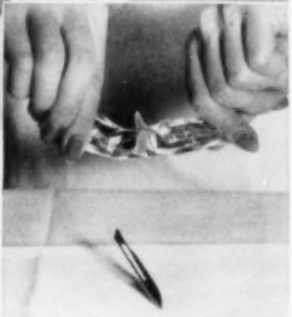

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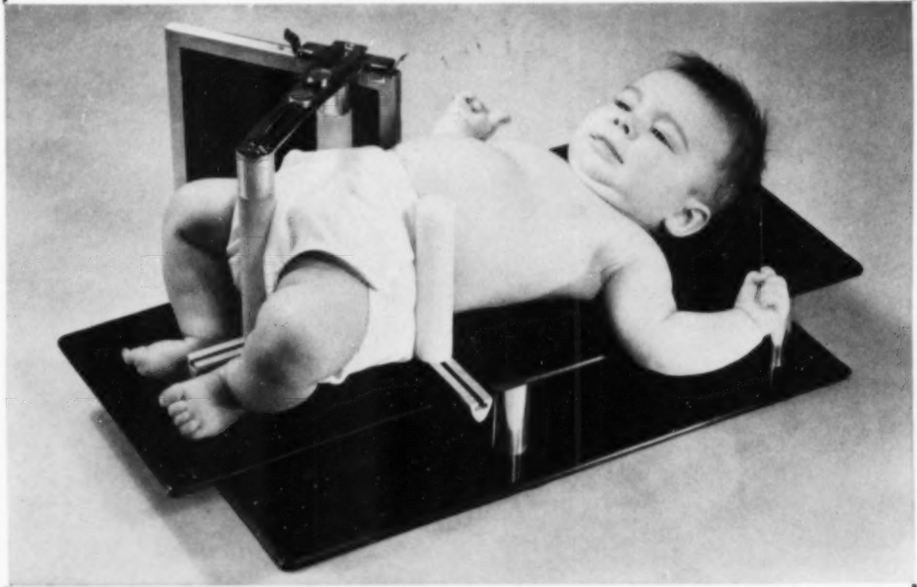

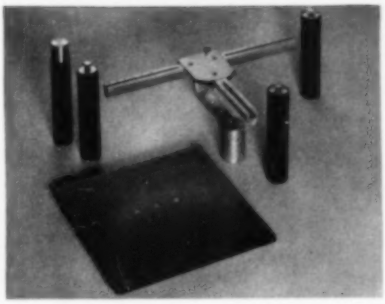

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Steam PACK

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The Hydrocollator Steam Pack is a fabric envelope containing a special heat retaining gel filler. When immersed and heated in water it becomes an efficient hot moist compress. It requires no wringing. There is no dripping. Simply wrap it in a turkish towel and apply to the area to be treated. Each application will give EFFECTIVE MOIST HEAT FOR AT LEAST 30 MINUTES. These packs can be used over and over.

When you prescribe supplementary thermotherapy in the home, the Steam Pack can be heated in hot water in any convenient vessel. For hospital or clinic the HYDROCOLLATOR Master Unit shown at lower right automatically maintains a supply of heated packs ready for immediate use.

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- **Positive and prolonged hyperemia.**
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- **The steam pack is accepted by the Council on Physical Medicine and Rehabilitation (AMA).**
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The Inside Story

on why you should use the

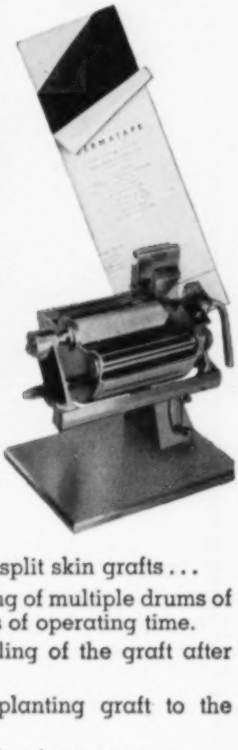
REESE DERMATOME

with

REESE DERMATAPE* TECHNIQUE

for simplified split skin grafting

*Trade Mark Reg. U.S. Pat. Off.



Several improved devices in recent years have greatly facilitated the excision of split skin grafts. None, however, has simplified the subsequent transfer and transplant of the graft to the lesion—*the most difficult and time consuming part of the operation.* The Reese Dermatape technique used with the Reese Dermatome so greatly simplifies the mechanics of skin graft transplanting as to reduce operating time, frequently, to one half or one third.

In brief, the Reese Dermatape technique for the excision of split skin grafts . . .

1. Permits the cutting of multiple drums of skin without loss of operating time.
2. Facilitates handling of the graft after excision.
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4. Eliminates suturing in most cases.
5. Assures a higher percentage of successful "take".
6. Conserves valuable operating time, and reduces hospitalization.

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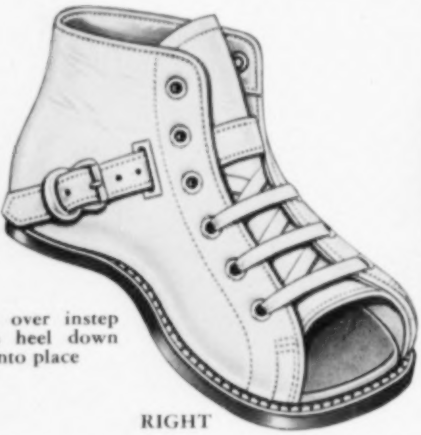
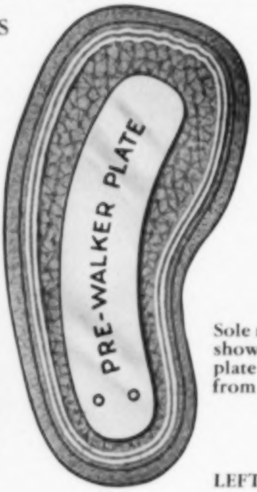


Strap over instep holds heel down into place

RIGHT



Sole removed to show flat steel plate extending from heel to toe

LEFT

DURING July 1952 the production at our plant passed the 100,000 pair mark, and the demand for Sabel Club Foot shoes, including Pre-Walkers, continues to grow. It is our constant purpose to match this demand by the expansion of our service. Right along new dealers are being added to our customer list. Inquiries are invited and any opportunity to be of service has prompt attention.

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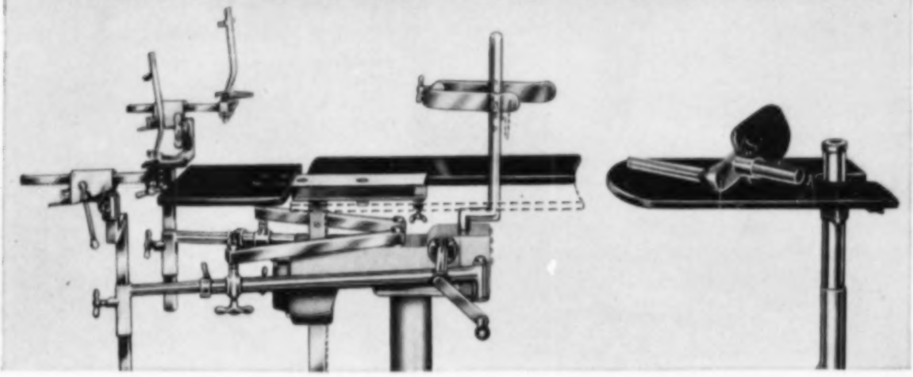
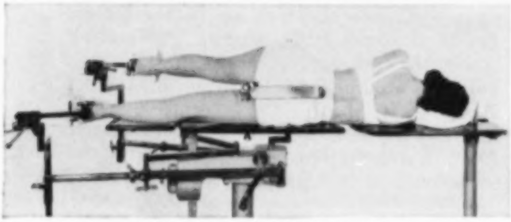
which provides full traction, flexion, abduction and adduction facilities plus unobstructed radiographic approach

. . . a featured accessory of the

"American" ALBEE-COMPER FRACTURE and ORTHOPEDIC TABLE





Stabilizes leg and holds it in traction.

Adducting offending extremity, the proximal fragment is exposed for driving the nail (or guide wire) retrograde.

These advantages will aid you clinically—

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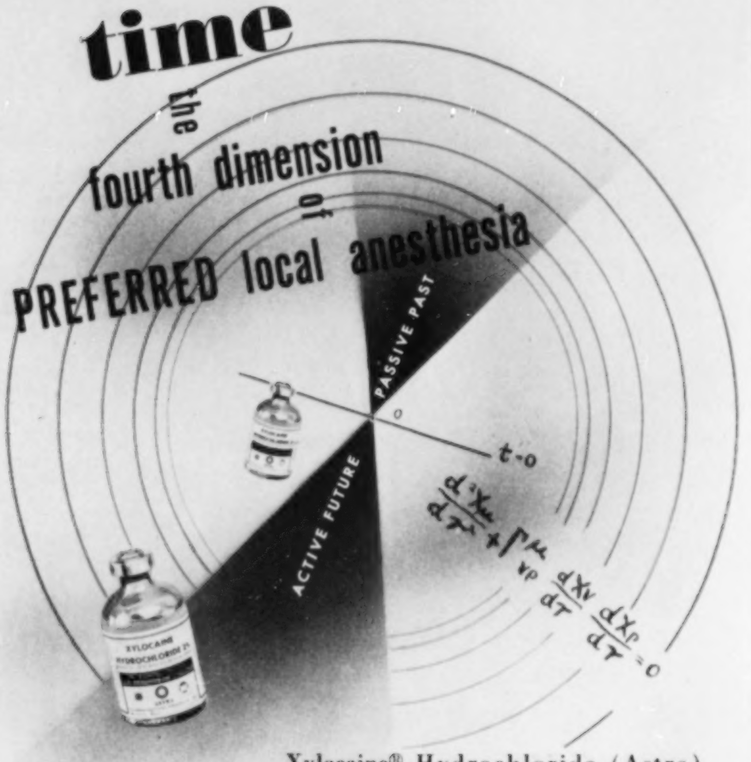
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fourth dimension
of
PREFERRED local anesthesia
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ASTRA PHARMACEUTICAL PRODUCTS, INC. WORCESTER, MASS. U.S.A.

*U.S. Patent No. 2,441,498

Bischoff Bulletin

No. 4
in a
series

treatment of subdeltoid bursitis and tendinitis

from the current literature on adenosine-5-monophosphate in acute subdeltoid bursitis

Twenty-six patients with acute and chronic subdeltoid bursitis were treated with MY-B-DEN. The great majority of the patients with acute bursitis, both calcified and noncalcified, were benefited, often dramatically. Some of the chronic cases also showed a good response. Two cc. (20 mg. per cc.) of Sustained-Action MY-B-DEN, injected into the gluteal region daily for three to six days, relieved most of the patients with *acute* subdeltoid bursitis. One patient with a chronic calcified lesion responded well to two injections weekly for four weeks. The authors note that one patient had three of the recognized indications for MY-B-DEN — phlebothrombosis, pruritus (ani and vulvae) and subdeltoid bursitis. Each of these conditions responded well to MY-B-DEN therapy.

Pelner, L., and Waldman, S.: The Use of Adenosine-5-Monophosphate in the Treatment of Acute Subdeltoid Bursitis, New York State J. Med. 52:1774, 1952.

These results confirm the earlier findings of Rottino. He used MY-B-DEN to treat 60 patients for tendinitis, with shoulder bursae involvement in 52. Clinical response was satisfactory in 54 of his patients. Of the 60 patients treated, 22 had chronic bursitis.

Rottino, A.: Adenosine-5-Monophosphate in the Treatment of Tendinitis, Journal Lancet 71:237, 1951.

The preceding papers are among the many referring to adenylic acid, muscle adenylic acid, and adenosine-5-monophosphate, all based on Bischoff's MY-B-DEN and its therapeutic uses. A complete bibliography on the use of MY-B-DEN in various conditions is contained in Bischoff Bulletins Nos. 1-2, which will be supplied on request.

adenylic acid for systemic therapy

MY-B-DEN®
(adenosine-5-monophosphate)

The medical profession has been expressing ever-increasing interest in adenylic acid (MY-B-DEN). It is being widely used for both established and experimental indications, as a nontoxic source of ATP in the body. The above articles concern the therapeutic value of MY-B-DEN in the treatment of acute subdeltoid bursitis.

available dosage forms:
intramuscular: Sustained-Action (10-cc. vials) and aqueous (1-cc. ampules)
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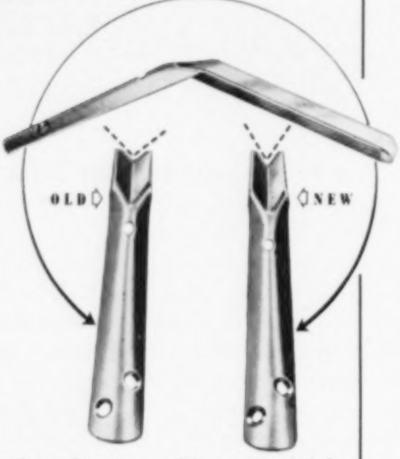
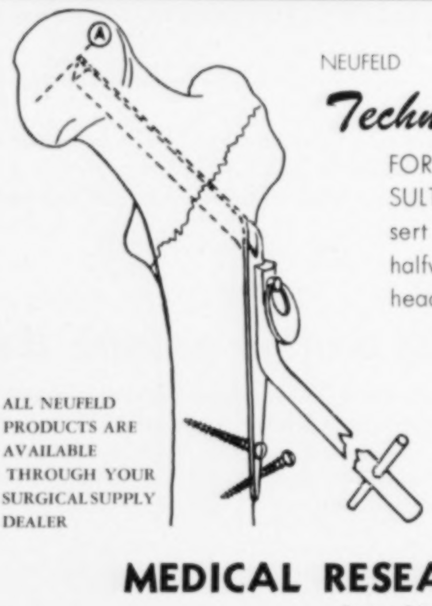
NEUFELD "Advanced Design" ORTHOPEDIC INSTRUMENTS

The Improved
NEUFELD NAIL



The improved angle design and finer, stronger metals provide over 20% increase in strength by actual test. The original Neufeld Nails have proven satisfactory in thousands of applications. Now, the "Advanced Design" gives added strength and security. For all internal fixations of the trochanteric area — *Specify Neufeld!*



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FOR THE BEST RESULTS — ***NEVER*** Insert Nails more than halfway through the head of the Femur

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The New
NAIL-INSERTING DRIVER
An excellent light-weight driver of unusual strength for those who prefer to use a guide wire.

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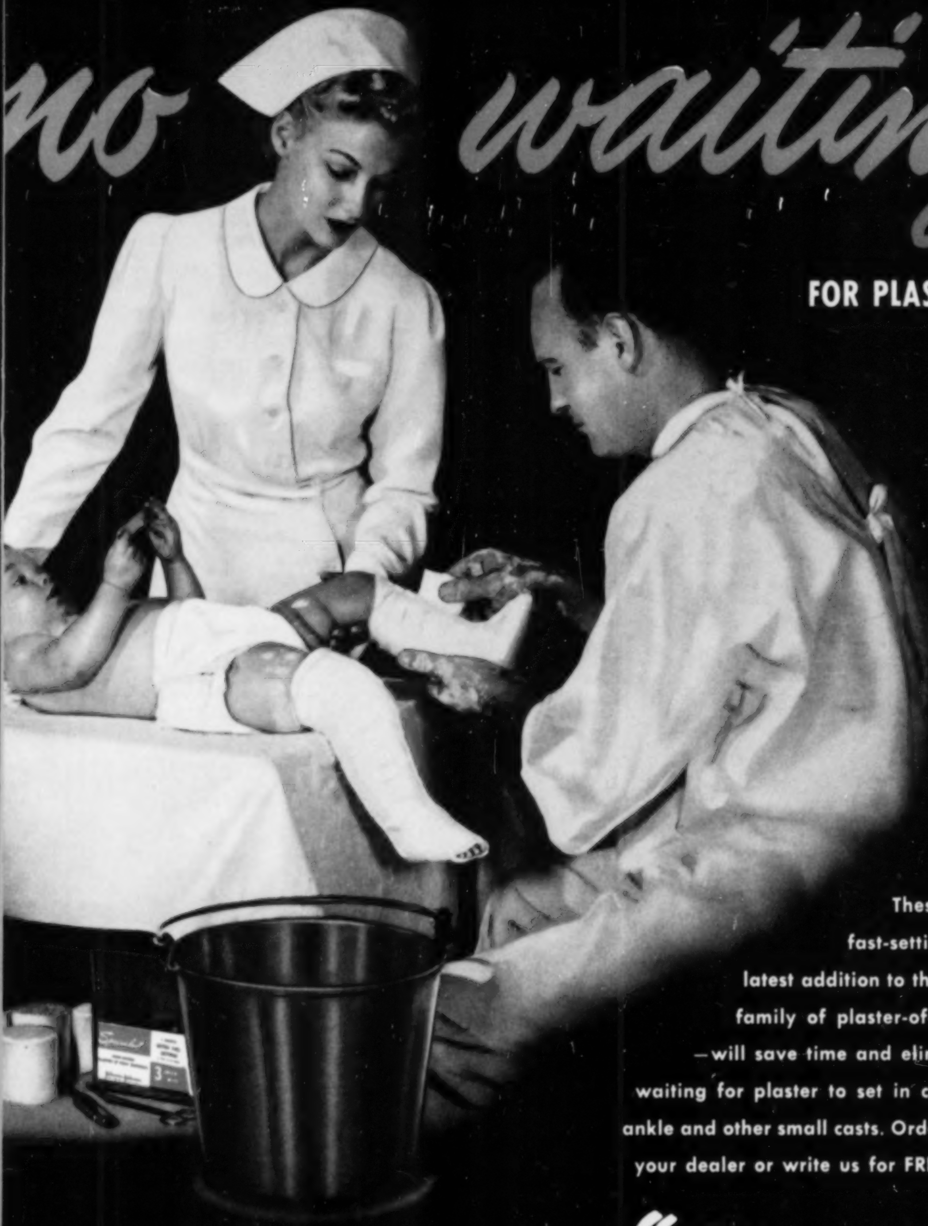

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INCHES WIDE
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no waiting

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BANDAGES

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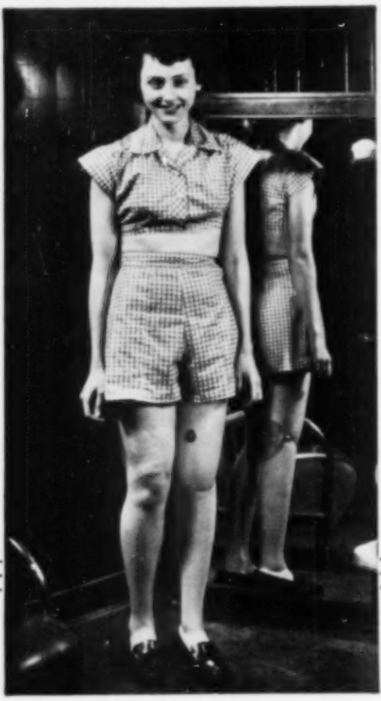

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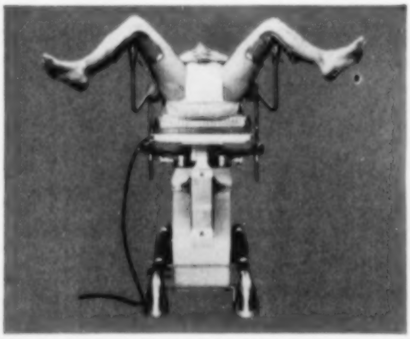

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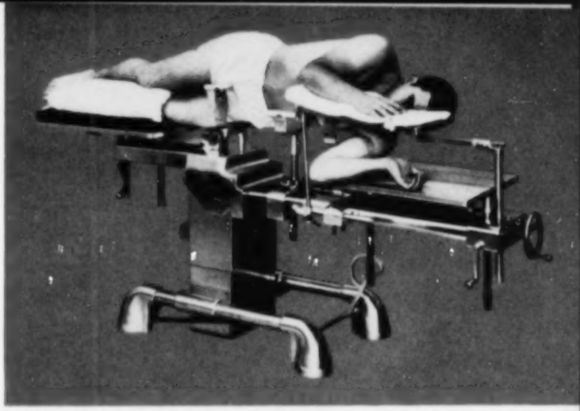

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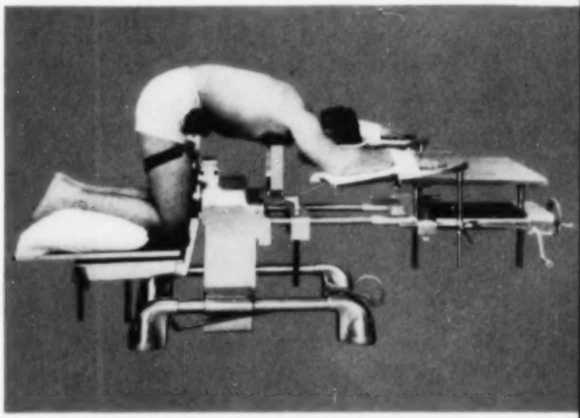

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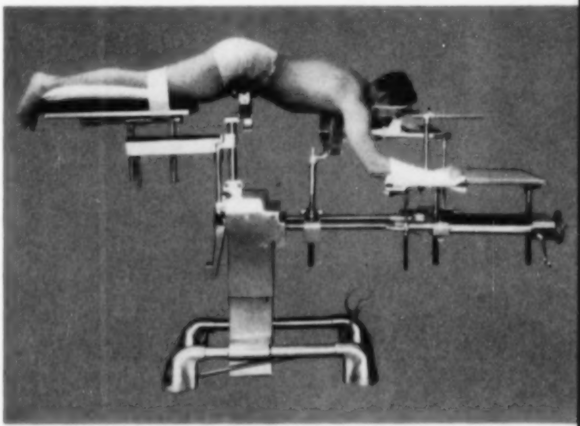
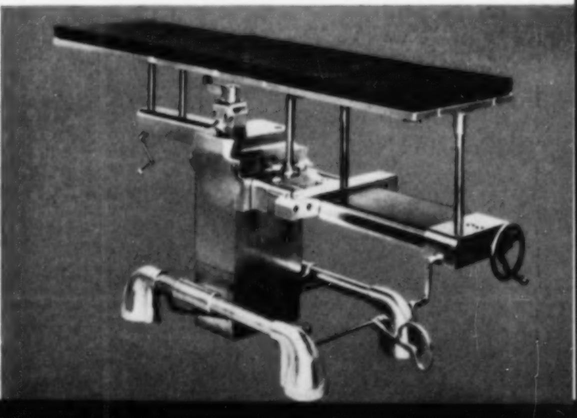


Cardiac—Thoracic—Neurosurgical



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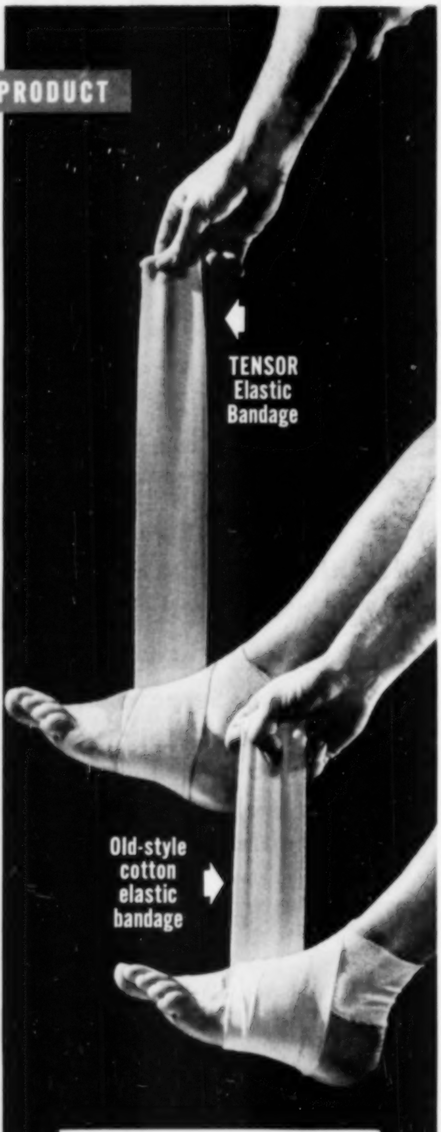

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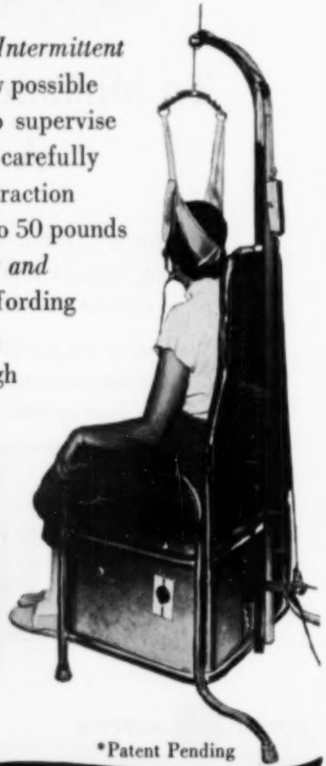

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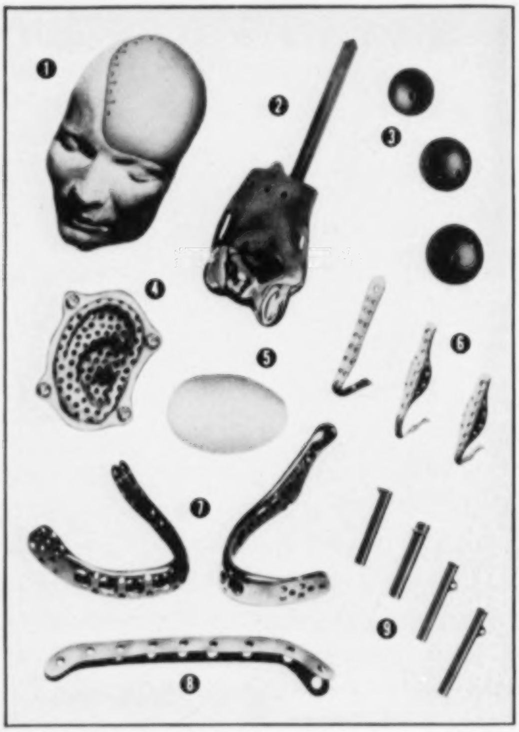

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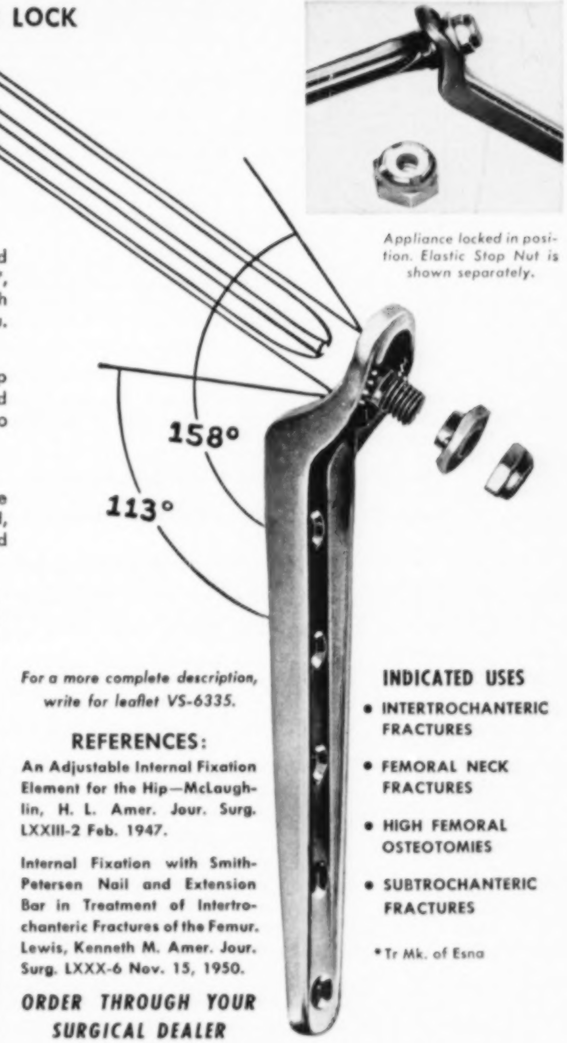

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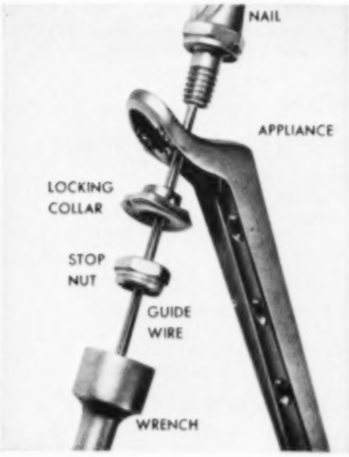

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REFERENCES:

An Adjustable Internal Fixation Element for the Hip—McLaughlin, H. L. Amer. Jour. Surg. LXXIII-2 Feb. 1947.

Internal Fixation with Smith-Petersen Nail and Extension Bar in Treatment of Intertrochanteric Fractures of the Femur. Lewis, Kenneth M. Amer. Jour. Surg. LXXX-6 Nov. 15, 1950.

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JANUARY 1953

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VOL. 35-A, NO. 1 JANUARY 1953

The Journal of
Bone and Joint Surgery

American Volume

PRESIDENTIAL ADDRESS *

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS

We meet here today with a feeling of nostalgia for the intimate sessions we have enjoyed so many times in the past, as the guests of illustrious past presidents, some of whom are now with us. This feeling is dispelled in great part by the friendly gracious hospitality and scientific stimulus afforded all of us by our orthopaedic friends of Great Britain. We need no interpreters of words or thoughts, and we revel in the surroundings of antiquity and tradition. This meeting is truly international for the English-speaking countries of the world. It will aid in forging even closer bonds between our countries by the scientific exchanges and personal contacts which it provides.

International relationships are of modern times. They are fraught with misunderstandings which inevitably arise from varied historic, geographic, economic, and linguistic backgrounds. Even the word "international" is new. It was never heard of in the English language until, in 1780, it was coined by Jeremy Bentham. The word "international" never passed from England to France until about 1840. It appeared for the first time in the dictionary of the French Academy in 1877.

The closer relationship and understanding engendered through the channels of scientific discussion and social intercourse will have no mean effect upon the economic and political relationships between our several countries. This mutual understanding can be brought about without the sacrifice of those valued national characteristics which insulate us.

This is the sixty-fifth meeting of The American Orthopaedic Association. It continues the series of the annual assemblages of outstanding orthopaedic surgeons of America. The continuity of these assemblies has been interrupted but once, that during the war year of 1945. We revere the memory of the founders, who, under the leadership of Dr. Virgil P. Gibney, had the courage and foresight to establish orthopaedic surgery as a separate and distinct branch of surgery. The American Orthopaedic Association was organized formally in 1887.

In 1894, Dr. A. M. Phelps defined the orthopaedic surgeon of the future as: "a man who has been thoroughly schooled in all the departments of medicine, who will have a perfect knowledge of pathology, surgical bacteriology, and anatomy". In 1896, Dr. Royal Whitman defined the scope of orthopaedic surgery as: "that division of surgery which treats of disabilities and diseases of the locomotor apparatus and of the prevention and treatment of deformities of the framework of the body". Compare these quotations, if you will, with those now contained in the prescribed requirements of The American Board of Orthopaedic Surgery, and you will find that our objectives remain the same.

The progress of orthopaedic surgery has been accelerated by the contributions and interest of each member of this Association. At present, orthopaedic surgery is recognized throughout the world as one of the outstanding specialties of medicine. This progress has not been without opposition from many quarters. It has been said that, "if a clam stirs in the mud, it is probable that some other clam is affected, objects, and criticizes. Criticism is a sign of 'something doing'. It is presumptive evidence of life." This has been true of the advance of orthopaedic surgery. Opposition will continue, although at an ever diminishing rate.

---

* Read in abstract at the Annual Meeting of The American Orthopaedic Association held in London, July 3, 1952.

In 1936, the House of Delegates of the American Medical Association took action to eliminate orthopaedic surgery from its position as a recognized specialty. Fortunately our specialty had been foresighted enough to have organized its Board and to have been able to influence the Advisory Board of Medical Specialties to negate such action. Reflect for a moment on this situation, and you will realize our predicament had the final action been otherwise.

Again, during World War II, a consultant called to Washington by the Surgeon General to help in classifying men assigned to the Orthopaedic Section of the Army, in his report of August 5, 1943, said: "I question seriously the wisdom of the assumption that the wounds of the extremities should be assigned to orthopaedic sections". In closing his report he further states: "Finally, my suggestions are (1) that the cases assigned to the orthopaedic sections be limited to cases referred to above as Group I with the addition of the knee derangements and the late care of amputations, (2) that the fractures, simple and compound, and other extremity wounds be referred to the general surgical sections". In this report, Group I reads: "'Old-fashioned' orthopaedic cases: the congenital and acquired deformities, such as talipes, scoliosis, post-infantile deformities; the chronic infections of bones and joints, especially tuberculosis; weak backs and weak feet".

It was the good fortune of orthopaedic surgery that Surgeon General Norman Kirk had other ideas which prevailed. The role of orthopaedic surgeons in World Wars I and II speaks for itself.

In his Presidential Address, Dr. LeRoy Abbott reviewed the academic status of orthopaedic surgery in the medical schools of the United States. He found that, in many institutions, our specialty labors under restrictions, imposed by others in relegating it to the minor specialty classification. We deplore this situation selfishly, but, as we scan the progress of orthopaedic surgery since 1887, we may rest assured that achievement will balance the scales.

A review of the development of orthopaedic surgery is unnecessary, for a comprehensive up-to-date compilation is available to all of us in that remarkable historic review published in *The Journal of Bone and Joint Surgery*, British Volume, November 1950. We are greatly indebted to Dr. Leo Mayer for the comprehensive review of the history of orthopaedic surgery in America. The study of this particular treatise might well be a requirement for qualification for certification. Certainly questions on this subject would not be amiss during the oral phases of the examination; to be of optimum effect, this should take place during Part I. It would thereby provide a firmer foundation for a sound understanding of orthopaedic surgery with its multitude of ramifications. It would acquaint the candidate with the accomplishments of the great surgeons who have brought this specialty to its present position.

The American Board of Orthopaedic Surgery began to take form at a meeting of the American Medical Association held in Milwaukee, Wisconsin, in the Spring of 1933 In 1934, during the meeting of this Association at Rochester, Minnesota, formal organization was consummated. The Board has functioned regularly since that time with ever increasing influence. It has improved the means and methods of training for aspiring surgeons. Nearly every member of this Association has contributed to its success by his participation in the examinations. Great personal sacrifices have been willingly accepted in behalf of the Board by those members who have and are shouldering its major responsibilities.

That certification by The American Board of Orthopaedic Surgery, as well as by other medical and surgical specialties, has contributed to improvement of standards cannot be denied. The certification of 2,013 orthopaedic surgeons as qualified specialists in this branch of surgery attests to the tremendous expansion of this field of endeavor. Although the results of the certification program are generally viewed in a favorable light, two phases, which are questionable, come up for consideration.

First is the undue importance attached to the action of the Board in its granting of a certificate. Many organizations are only too anxious to utilize this screening to modify their own responsibilities in determining the qualifications of candidates for various appointments. The holder of a Board certificate gets preferential consideration in his application for membership in professional societies, in the Medical Corps of the Armed Forces, in State Crippled Children's Programs, and for hospital and academic appointments. This may be the just desert of the diplomate, but until the examinations become much more rigorous, even extending into clinical and operating performance, the certificate becomes only the first distinction separating its holder from the general herd. It is but the first rung of the ladder. As higher rungs are reached, recognition depends more and more upon the intangibles of performance, character, and leadership. By keeping its standards at the highest level, The American Orthopaedic Association can always be the goal of those now on the first rung.

A second defect in the certification program is the tendency to compart medicine by walls of ignorance of what is taking place in other branches of medicine and surgery. This was illustrated only too well at one of the Board examinations. A candidate was asked about the present knowledge of the etiology and transmission of anterior poliomyelitis. He exclaimed with great indignation that he had come before the Board to be examined in orthopaedic surgery and that the query belonged in the field of internal medicine. All too frequently the isolation of our special hospitals and orthopaedic services prevents us from widening our horizons in the consideration of the patient as a physiological entity. In order to provide a better understanding of the basic principles of medicine, using the term in its broadest sense, we must absorb the knowledge of newer methods of investigation. The chain reactions of the endocrine glands, the significance of trace minerals, the maze of nutritional factors, as well as the field of isotopes employed as tracer elements, and the revelations of the electronic microscope must be explored. Orthopaedic surgery is far from being alone in its isolation. Our specialty has shown the remarkable ability of being able to emerge from the strictly mechanical and technical consideration of our problems. The increase in the number of basic-science papers published in our *Journal* reflects this progress. The scientific programs of our major orthopaedic societies still reflect the clinical, as well as the technical, phases of our work with relatively meager evidence of real investigative activity in the basic fields of surgery.

We have left much of the undergraduate instruction in the fundamentals of surgery to be presented by the departments of general surgery. When we consider the initial impact made on the student just entering his clinical experience, we can understand his attitude toward orthopaedic surgery. He is apt to disparage our efforts and, unless attempts are made to amend his first impression of orthopaedic surgery, he may carry this impression indefinitely. If this be true, the solution would seem to be obvious. As orthopaedic surgeons, we should take advantage of every opportunity to present basic surgical principles and technique in the early years of the medical curriculum. Demonstrations in anatomy, instruction in history-taking and in physical diagnosis are great occasions for the young student when they are correlated with specific clinical problems. To confine our efforts to the instruction of residents and students at the graduate level may be more interesting in many ways, but to do so is a disservice to medicine in general and to our chosen field in particular.

The American Board of Orthopaedic Surgery has granted certificates to a total of 2,013 orthopaedic surgeons to date. Of these, 116 have passed on to their final reward. The American Academy of Orthopaedic Surgeons has a membership of 1,395 and a necrology list of 163. A consideration of these figures reveals that, of a total of approximately 150,000 active regular medical practitioners, orthopaedic surgeons constitute but about 1.33 per cent. of the profession. This estimate does not include those surgeons who have not met the qualifications of the Board.

The American Medical Association estimates that the total of hospital admissions reaches the astounding figure of 18,000,000 annually. The average occupancy of hospital beds is 450,000. No figures which would reflect the various clinical classifications are available, and only rough estimates can be made. The Bureau of Statistics estimates that from 15 to 20 per cent. of hospital admissions might be classified as orthopaedic if the criteria used by the Army are employed. These figures, although estimates, indicate that a major part of the care of these patients remains under the direction of the general practitioner and the general surgeon.

If by our activities in teaching centers or by an increasing participation in general medical meetings we can improve the lot of these patients, credit will eventually accrue to the orthopaedic surgeon and to his position in the profession. The lay estimation of orthopaedic surgery will reach even higher levels than is now the case.

A step in this direction, that is an effort to familiarize the undergraduate student with the scope of orthopaedic surgery, is being taken by your Committee on Undergraduate Teaching. An outline of the fundamentals of history-taking and of examination from the standpoint of orthopaedic surgery for the use of instructors who may wish to employ it in their classes is now in preparation. Such guides as are now used in various localities have been assembled and the elements of greatest importance incorporated in this new booklet (Manual of Orthopaedic Surgery*). It is hoped that, with your criticisms and cooperation, this small volume will eventually become part of the library of most of the medical students in this country and that it may remain with them throughout their professional careers. This initial cooperative effort in undergraduate teaching can be extended into many other phases of orthopaedic instruction without treading on the prerogatives of individual instructors.

The American Orthopaedic Association includes in its membership most of the Professors of Orthopaedic Surgery of the many medical schools of the United States as well as a large number of instructors. This fact places our Association in a unique position to contribute to the formulation of an efficient and aggressive, yet elastic, teaching program for the undergraduate medical student. The senior position of our organization carries with it the obligation of leading the way in educational efforts as they relate to our scope of activity. Would it not be proper and fitting for us to add impetus to such a program by devoting a portion of our annual meeting to this question? Those of us who are in the teaching saddle would be pleased to participate. Others could contribute from their long experience. Still others who might not be interested could yield to their diverse desires. The interest of our members in such a program was reflected by the large attendance at the special session at Quebec.

If such a program should be sponsored by this Association, financial support might well be anticipated from some of the large foundations especially interested in medical education. If such a program as has been briefly outlined above should be endorsed, our Association would have a goal which might eventually approach that now attained by our *Journal*,—that is, to lead the field.

A presidential address, with its traditional freedom from rebuttal, affords its writer the opportunity to express some of his thoughts, to wander from the past into the future, and to whisper suggestions which come to mind. It also presents an opportune moment in which to thank the members of The American Orthopaedic Association for the high honor which comes with the office of President. To have had the privilege of working

(*Continued on page 54*)

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* See advertisement, page 43.

INTRAMEDULLARY FIXATION IN FRACTURES OF THE HAND AND FINGERS*

BY FREDERICK H. VOM SAAL, M.D., YONKERS, NEW YORK

There are many effective methods for obtaining union in fractures of the hand. The method to be presented is as effective as other methods in obtaining alignment and union, and it is far superior to most in the preservation of function and in the reduction of economic loss.

Many of us are loath to subject simple fractures of the hand or the fingers to surgery because union and alignment can usually be obtained without operation. The author has, however, operated increasingly in such cases, because of the great saving to the patient in money, time, and function. In malunion and in reconstruction, the intramedullary pin has obvious advantages; in fresh simple fractures, treatment by pinning has been routinely

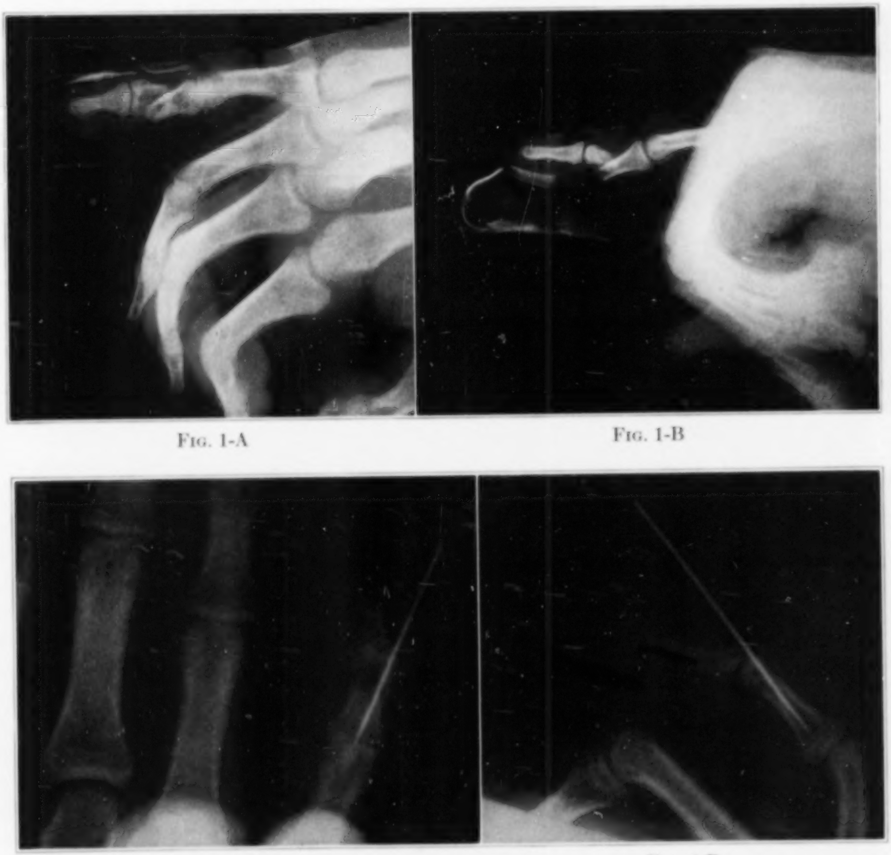
FIG. 1-A

FIG. 1-B

FIG. 1-C

FIG. 1-D

Case 1. Patient sustained a displaced fracture of the middle phalanx which was treated by closed reduction under local anaesthesia and needle fixation. Healing occurred within four weeks, at which time the needle was removed.

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* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 25, 1952.

used if the fracture was displaced or if it was important to the patient to be able to use his hand immediately, as is frequently the case when the patient is self employed. Not

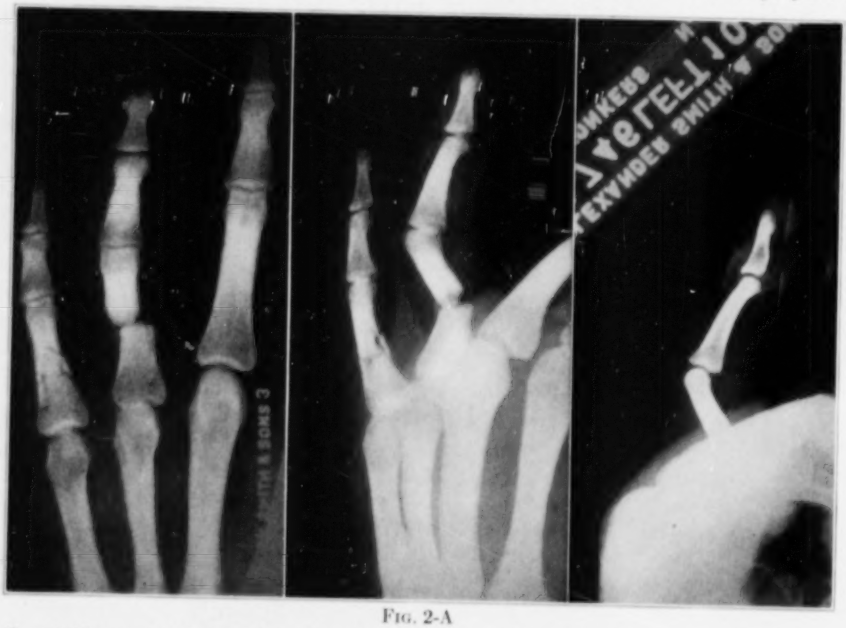

Fig. 2-A

Case 2. Five weeks after the fracture, non-union with rounding of the bone ends was developing.

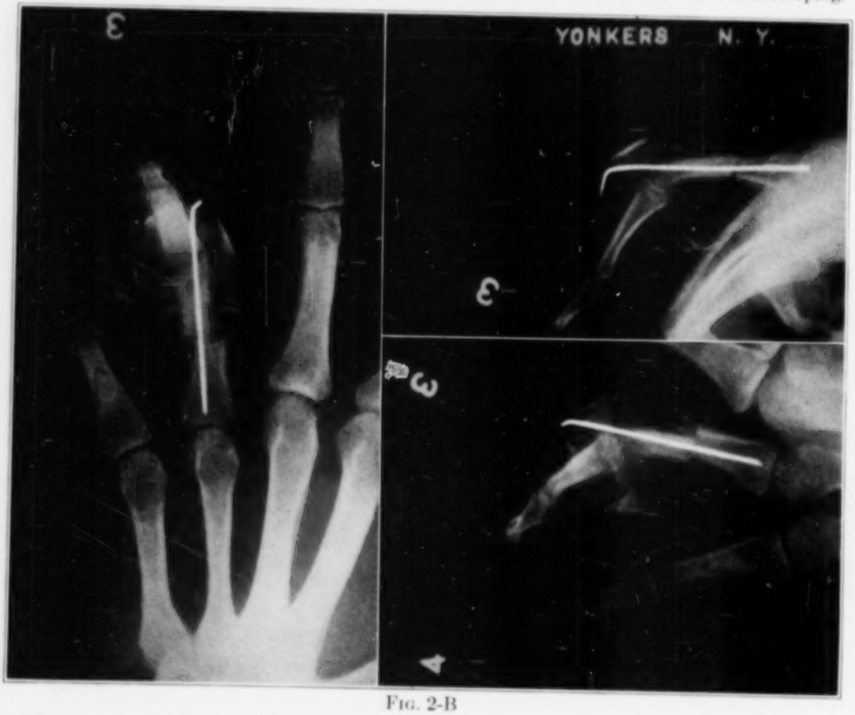

Fig. 2-B

Three weeks after open reduction, pinning, and the application of a bone graft, the patient was back at work. He regained full function in about a month.

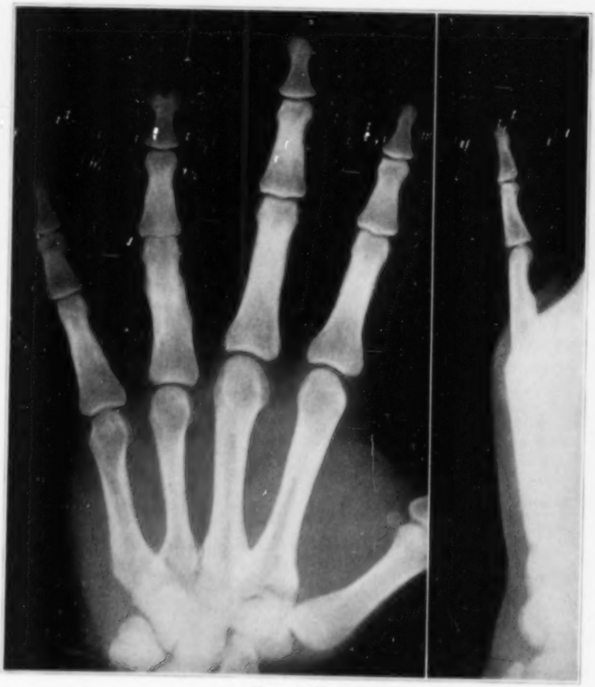

FIG. 2-C

More than five years later, the x-rays showed no apparent joint damage from the pin. The patient has full use of his hand.

all simple fractures have been pinned.

This method is applicable to many types of injuries of the hand and fingers—both soft-tissue and bone injuries. It has been used for the fixation of fractures and in osteotomies, repair of non-union, bone-graft fixation, fusion of joints, reposition of amputated finger tips, and splinting for extensor-tendon avulsions. For compound fractures, the indications are the same as those for any other form of internal fixation. If the wound can be made surgically clean within four hours of the injury, pinning may be used.

Severely comminuted fractures should not be pinned. Pins should also not be used if there are furuncles, blisters, or loss of skin, or if there is general sepsis.

The economic loss from even relatively simple fractures of the fingers and hand is often considerable. Such fractures are not easily splinted without interference with the function of the rest of the hand, especially if the index or middle fingers are involved. The several months spent in regaining function may place a great financial burden upon a man with a large family, even if compensation has been allowed. Intramedullary fixation of such fractures allows the continued use of the whole hand; and, as a result, function is never lost.

FINGERS

Fixation of amputated or of partially amputated finger tips is much more secure if it is done by pinning, and the dressings are much less cumbersome. Because of the difficulty in inserting a Kirschner wire into the tip of the phalanx, a needle is usually used; it is inserted from the finger tip to the base of the distal phalanx. The needle can be removed in three to four weeks.

Both fractures of the middle and proximal phalanges are fixed in this manner. The pin is held in a hand chuck and is inserted from the distal end of the involved phalanx through the middle of the extensor-tendon sleeve at the edge of the joint. At this point the tendon is thinnest. The pin must be inserted with the joint flexed to 90 degrees to allow flexion of the finger afterward. Flexion to 90 degrees also facilitates the reduction of the fracture. The pin must be inserted almost to the other joint line in order to be well embedded in cancellous bone. To be certain that the pin has been inserted to the proper depth, one must check the position by x-ray. A needle can be used, but a .045 or .062 Kirschner wire is preferred. The end of the wire which protrudes through the skin is bent to a right angle in order that penetration of the joint may be prevented. A small piece of cotton and collodion is then put over the end of the wire to prevent extrusion of the

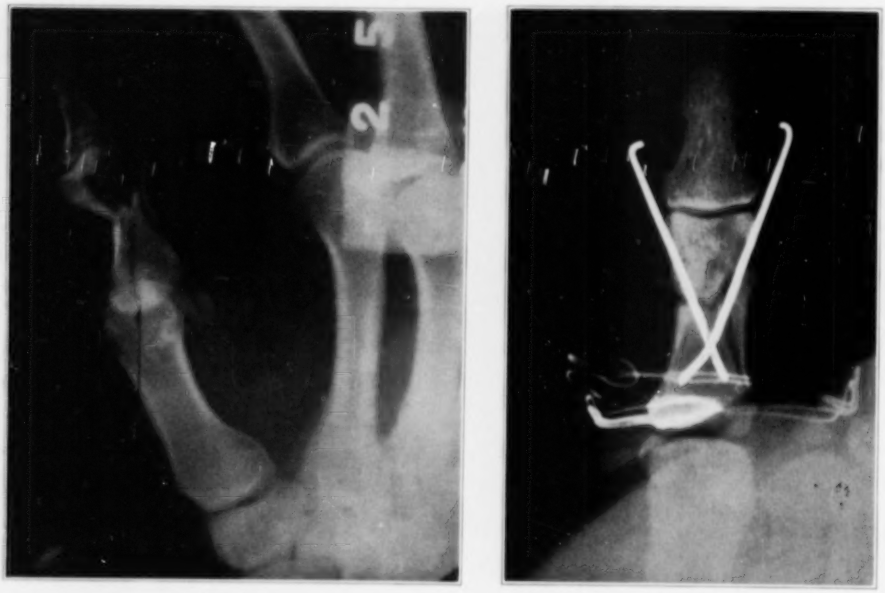

Fig. 3-A

Fig. 3-B

Case 3. Patient had compound fracture with tendon laceration which was repaired and fixed by pinning. Fractures of the thumb phalanges usually require the use of several pins.

wire and to keep the skin wound clean. In from four to seven weeks, depending upon the type of pathological condition and the speed of union, the wires are removed. During the course of the procedure, an arm or finger tourniquet is always used. Closed insertion is used in most fresh fractures; open reduction is done in cases in which treatment has been delayed and in reconstructive procedures.

The patient is encouraged to use the hand as much as possible. If the pin has been properly inserted, flexion is complete; extension of the affected finger is usually to 140 or 150 degrees. The patient must not wash his hand, but he may clean it with a damp cloth.

After the pin has been removed, full extension is usually regained in from two to three weeks. A dressing is left over the pin hole for twenty-four hours.

Case 1. The patient, a man, thirty-eight years old, had a displaced fracture of a middle phalanx. Closed reduction under local anaesthesia with needle fixation was done. The patient returned to work in one week, and the pin was removed in four weeks, after healing had been obtained.

Case 2. The patient had a transverse fracture of the proximal phalanx which had been treated with a tongue-depressor splint. At the end of five weeks, non-union developed with rounding of the bone edges. Open reduction was done with pinning and the application of a tiny bone graft. The patient returned to work in two weeks and regained full function in about a month. In a roentgenogram (Fig. 2-C) made after a follow-up of more than five years, the first interphalangeal joint appeared to be entirely normal with no apparent damage to the joint from the pin. Of course, this does not prove that the joint will never show damage, but five years is a reasonably long follow-up period.

Most fractures of the fingers are transverse or comminuted. Occasionally, however, one will see an oblique fracture in which this method cannot be used. The reason is obvious. The pin is not large enough to fill the canal of the phalanx; and the fracture fragments, therefore, slide until the opposite sides impinge against the pin. Reduction is lost and function is impaired.

Fusion of an interphalangeal joint is occasionally necessary because of painful traumatic arthritis, soft-part injury to the joint or tendons, or rheumatoid arthritis.

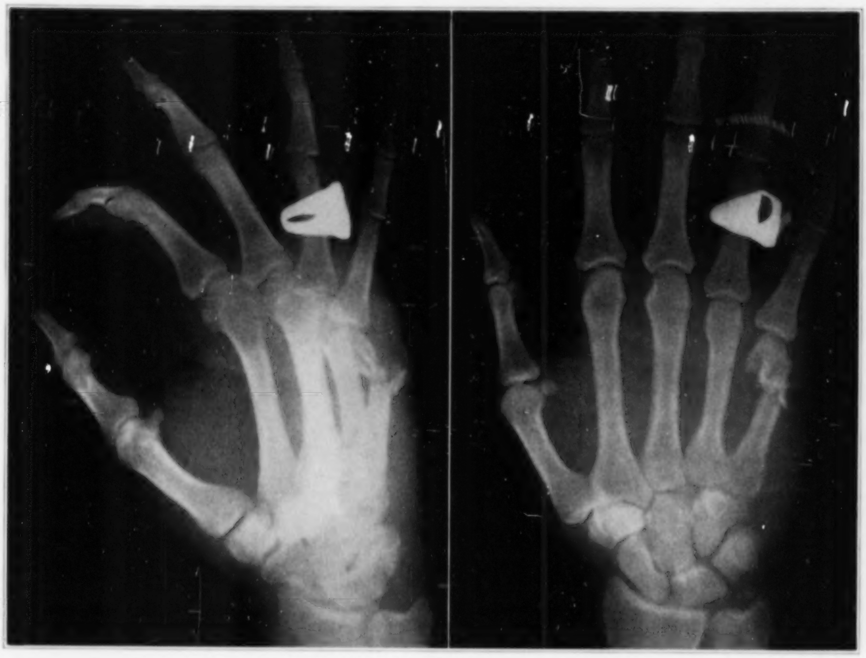

FIG. 4-A

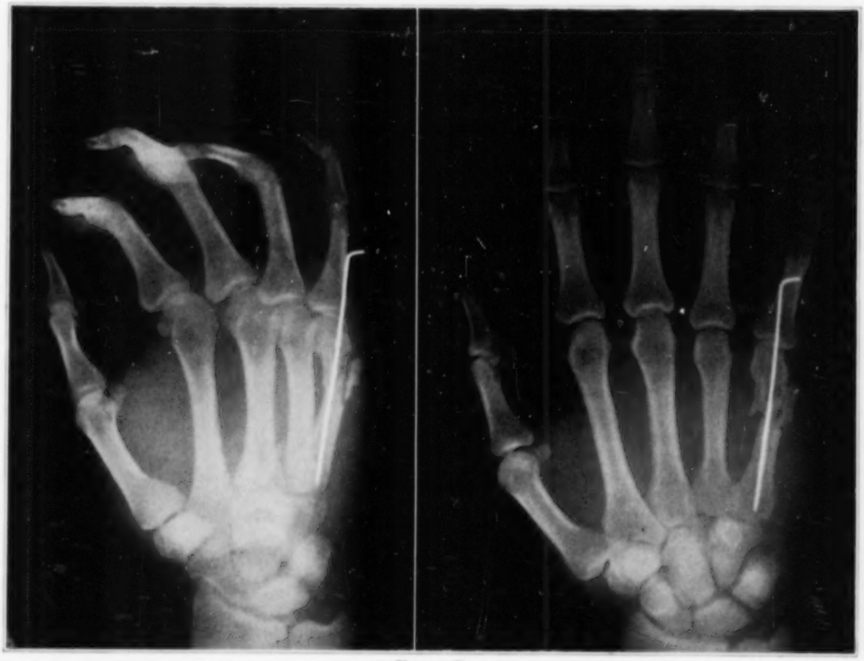

FIG. 4-B

Case 4. Patient had a comminuted fracture of the metacarpal head which was adequately reduced and fixed with pinning. The pin was removed in six weeks.

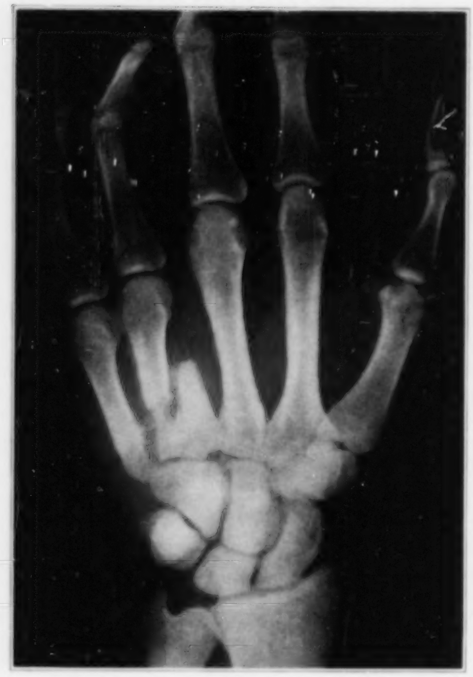

Fig. 5-A

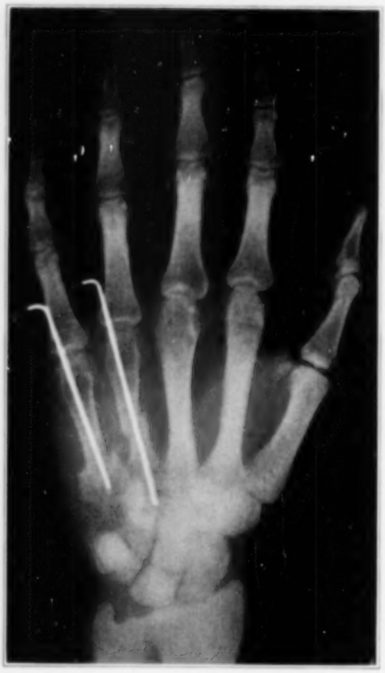

Fig. 5-B

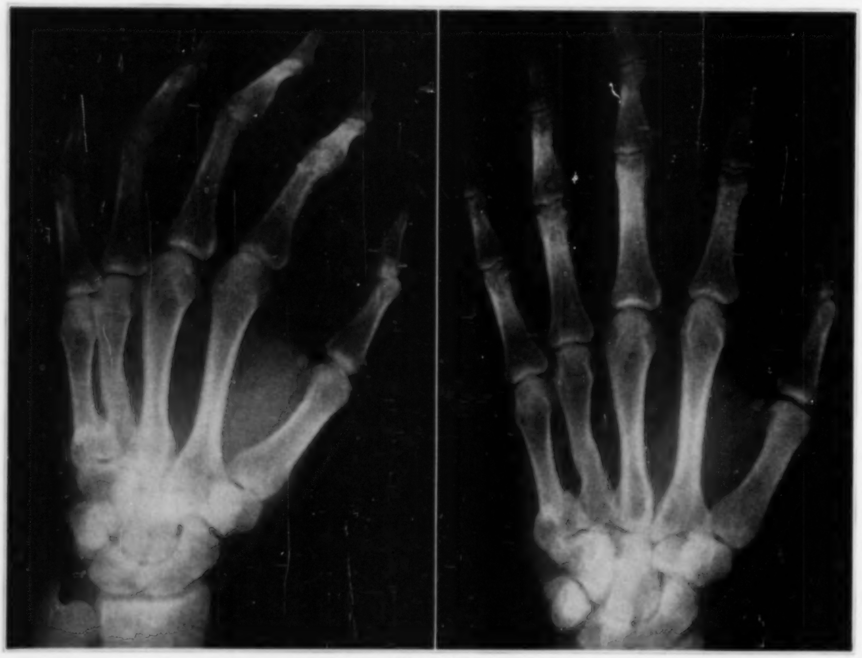

Fig. 5-C

Case 5. Patient had displaced fractures near the bases of the fourth and fifth metacarpals. Open reduction was done and the fragments were pinned into the adjacent carpal bone. There was no apparent joint damage as shown by x-ray three years later.

Pinning provides an excellent means of fixation and allows function of the rest of the hand while union is taking place. In addition to joint resection, small bone grafts should always be used.

Fixation of mallet fingers by the blind insertion of Kirschner wires has been previously described.[1] The present author has used a similar method, but he has limited the use of wires to those patients with complete avulsion in whom tendon fixation had also been done. One should distinguish between partial and complete tears; for the latter, the author feels that the results are far better with resuture of the tendon. In women, a .045 Kirschner wire is frequently large enough; in men, a .062 wire is usually used. A small L-shaped incision is made across the dorsal surface of the distal joint. As the tendon is torn and retracted, the joint is immediately entered. The wire is then inserted into the dorsum of the proximal end of the distal phalanx at the joint line and is drilled out of the end of the finger. The drill is then placed at the opposite end of the pin and the finger is hyperextended. The wire is drilled into the middle phalanx. According to the degree of hyperextension, the wire will either go through the palmar surface of the phalanx and into the proximal phalanx or it will remain in the intramedullary canal all the way and go through the middle phalanx into the proximal phalanx which is held, with the joint flexed, at a right angle. Drilling is continued until the wire is felt beneath the skin on the dorsum of the proximal phalanx. The wire is withdrawn a bit until it rests in the bone of the proximal phalanx. Fixation is then quite secure. Two fine silk mattress sutures are used to approximate the extensor mechanism, and the skin is closed with two or three silk sutures. The pin which protrudes from the end of the finger is bent over, and is covered with cotton and collodion. The patient is allowed to use the rest of the hand as freely as possible. He may occasionally be disturbed by the appearance of his finger and should be warned about this ahead of time. The pin is left in place for approximately four weeks; full function is usually regained in two or three weeks after its removal.

Pinning is seldom indicated for injuries of the thumb, for most fractures of the thumb are too comminuted to allow pin fixation. Also, the medullary canal of the thumb is quite wide, and a single wire does not usually provide adequate fixation. Occasionally, one is able to secure fixation as was done in the following case.

CASE 3. The patient had a compound fracture through the dorsum of the thumb with laceration of the extensor tendon. After the fracture had been cleaned, two pins were inserted from the fracture site and were drilled out the two sides of the thumb; they were reversed and inserted into the proximal fragment where they crossed. Then the tendon was resutured. Fixation was quite secure and the patient immediately started using his hand and thumb. He returned to his desk job in ten days. The wires were removed in six weeks.

METACARPALS

Conservative management of fractures of the metacarpals usually causes a greater economic loss than do fractures of the fingers because external splinting frequently means that the patient is unable to return to work. Intramedullary fixation allows him to continue at work in almost all jobs except those in which the hands must get wet.

In the hand, intramedullary fixation cannot be used for as many different conditions as it can in the fingers; however, in the pinning of fractures of the hand there is much greater latitude. Frequently, moderately comminuted fractures can be pinned. The degree of obliquity is unimportant, because displacement is usually prevented by the support of the side structures. Simple fractures of one metacarpal can be blindly reduced and pinned; but, if the fractures are at all comminuted, or are multiple, open reduction is far simpler. If open reduction is done, it is always easier to insert the pin into the distal fragment from the fracture site. Whichever way the pin is inserted, it must come out on the radial side of the dorsal surface of the metacarpal head and be inserted with the metacarpophalangeal joint in full flexion. In this way, the greater part of the extensor-tendon mechanism is avoided by the pin and full flexion after pinning is allowed. If adjacent meta-

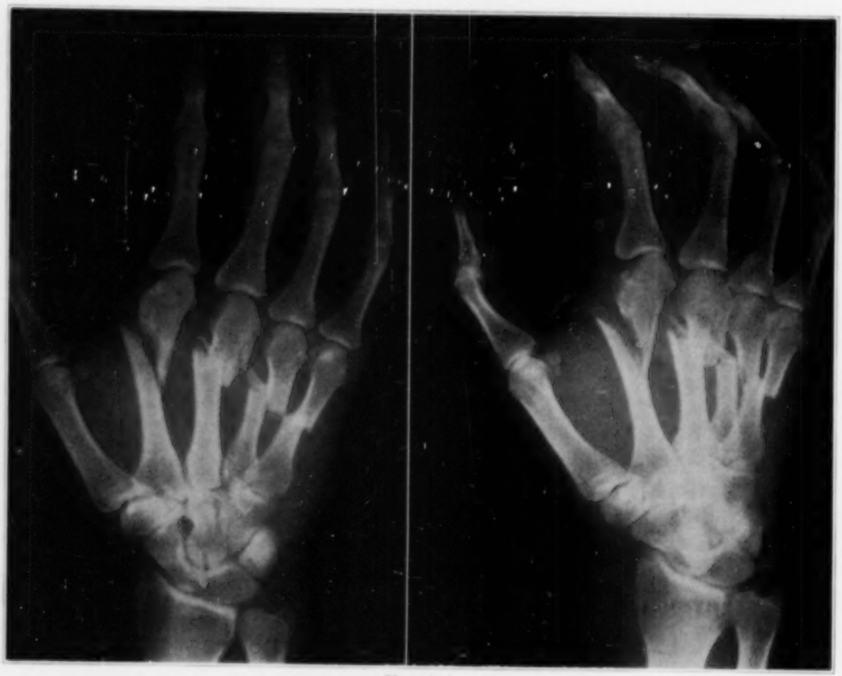

FIG. 6-A

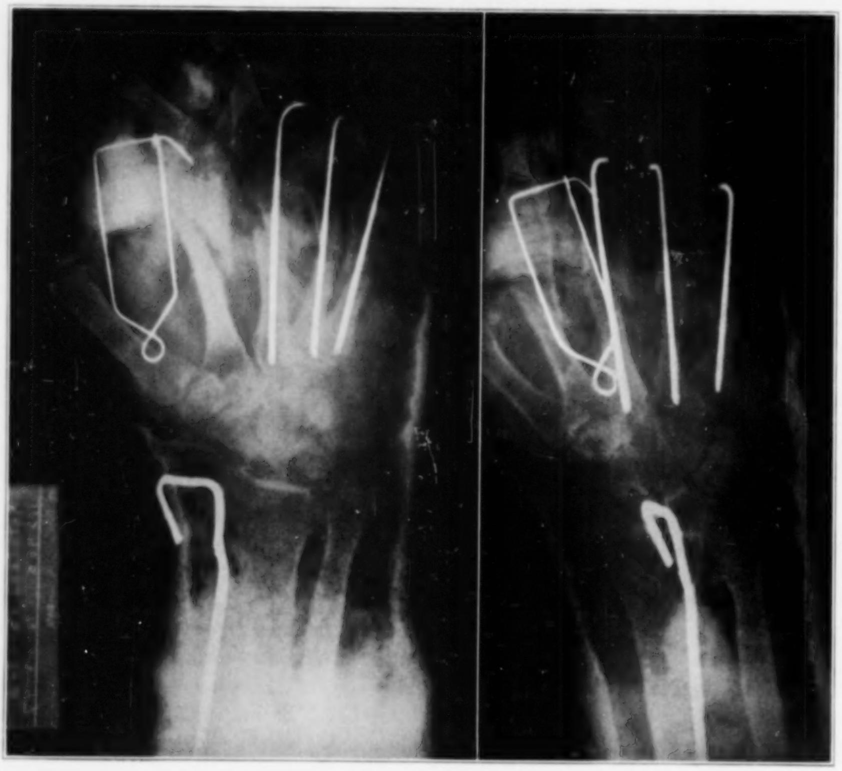

FIG. 6-B

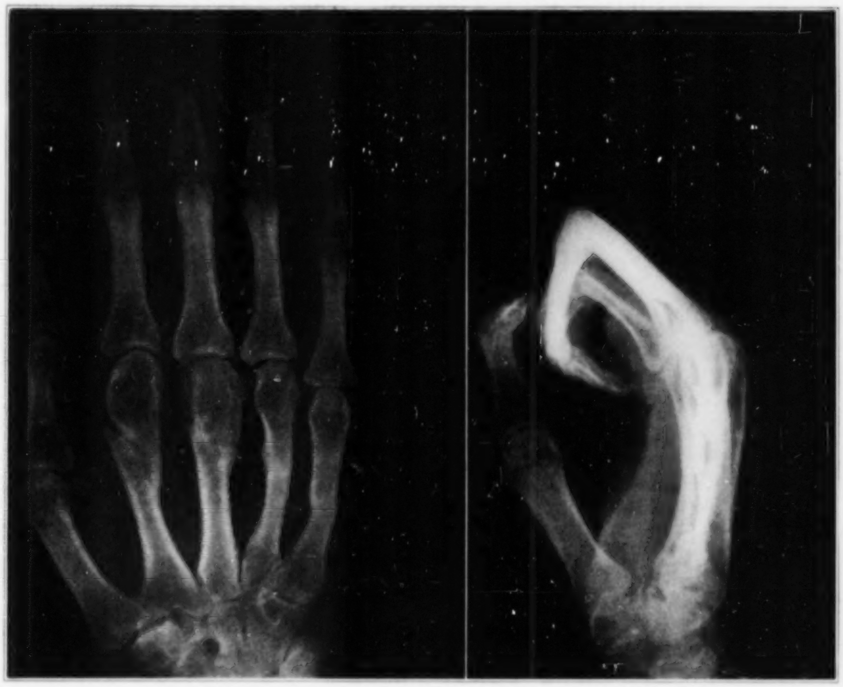

FIG. 6-C

Figs. 6-A to 6-C: Case 6. Patient suffered an extensively damaged hand in an automobile accident. Traction was applied to the second metacarpal because the fracture was severely comminuted. The other three fractures were treated by pinning. The patient regained complete function in two months.

carpals are fractured, a single incision between the bones allows adequate exposure for pinning, and the .062 Kirschner wire which is almost always used can be inserted by means of a hand chuck. The pins must extend to the base of the metacarpal into cancellous bone. If the fracture is near the base of the metacarpal, the pin should go through and into the adjacent carpal bone. No apparent damage results from this penetration of the joint.

CASE 4. In a fight the patient sustained a comminuted fracture of the metacarpal head which was adequately held by a pin. The fracture was treated by open reduction and the retrograde insertion of a pin. The pin was removed in six weeks.

A similar procedure can be done for simple fractures of the metacarpal head in adults and can also be done in children, if there is an open epiphysis when the fracture occurs. However, in treatment of such fractures, a finer Kirschner wire should be used—either .032 or .045, depending upon the size of the hand.

CASE 5. This patient sustained displaced fractures near the bases of the fourth and fifth metacarpals, which were treated by open reduction and by pinning into the adjacent carpal bone. He returned to work in five days, but he had lost the power of adduction of the fifth finger from the extensive damage to the intrinsic muscles. Roentgenograms made after a follow-up of three years showed that there was no apparent joint damage.

That pinning can be used in conjunction with other methods of treatment is illustrated by the following case.

CASE 6. This patient suffered an extensively damaged hand which was seen the day after an automobile accident. At open reduction the tissues were found to be brown, macerated, and filled with blood. The third,

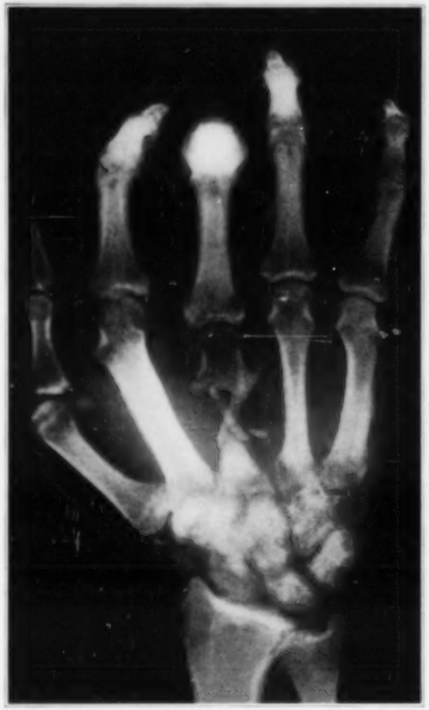

FIG. 7-A

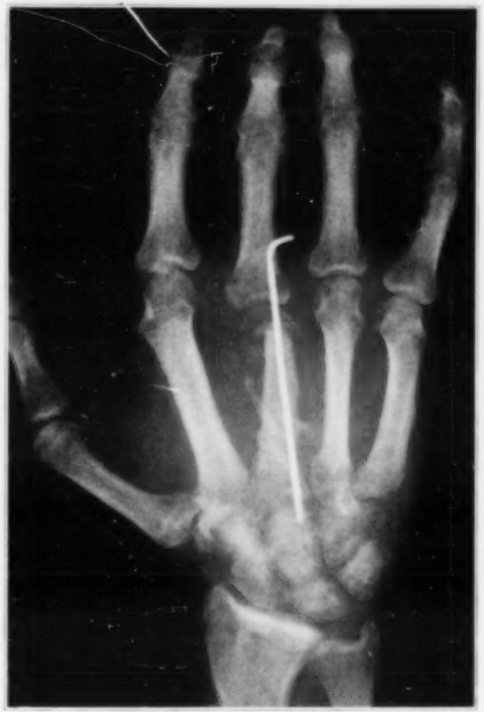

FIG. 7-B

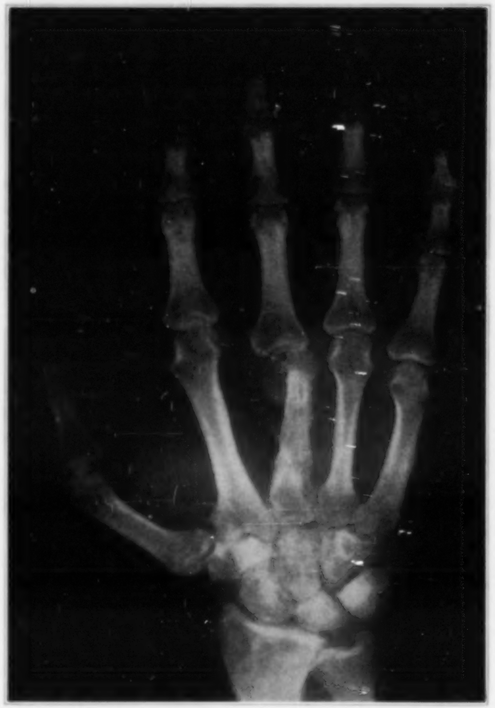

FIG. 7-C

Fig. 7-A: Case 7. X-ray made five weeks after the patient ran his hand into a drill press. By this time, pieces of bone had sloughed out of the wounds in the palm and on the dorsum of the hand; the extensor tendon had sloughed out. Infection was present and the hand was oedematous. The fingers were stiff as the result of immobilization. Note that the articular surface of the metacarpal remains in the metacarpophalangeal joint.

Fig. 7-B: After the wound had healed, a bone graft from the ilium was pushed up under the cartilaginous cap. A pin was used to fasten the cartilaginous cap onto the graft and the graft to the carpal bone. An extensor-tendon graft was also placed at this time.

Fig. 7-C: Roentgenogram made three months later. The patient had full active extension and he could touch his palm with his finger tips. He is now back at machine work and has not lost any time from work in the past three years.

fourth, and fifth metacarpals were pinned. Because of the marked comminution, the second metacarpal was not pinned. Traction was applied to the finger by means of a modified banjo splint. Motion was immediately started in the three unencumbered fingers and thumb. The pins were removed in five weeks, but residual stiffness of the index finger which had been in traction resulted. In two months, however, the patient was able to return to work as a typist with full function of the hand. Roentgenograms made after a follow-up of two years showed an excellent appearance and that the patient could touch the bases of her fingers and also the base of the palm.

It seems certain that, if this hand had been immobilized, there would have been marked loss of function.

Metacarpophalangeal fusion has not been done, but pinning works well in carpometacarpal arthrodesis. It is usually done for arthritis of the first carpometacarpal joint. The joint is resected and pinned, and a small bone graft is added. The pin can be introduced from the end or side of the proximal phalanx.

The following case illustrates the use of pinning in a complicated injury.

Case 7. This patient had run his hand into a drill press and was not seen until five weeks after the injury, at which time roentgenograms were made (Fig. 7-A). Pieces of bone had been sloughing out of the wounds in the palm and on the dorsum of the hand, and the extensor tendon had sloughed out. The patient was sensitive to penicillin and streptomycin, the only antibiotics available at the time. The hand and fingers were oedematous from the infection and had been immobilized so that all of the fingers were stiff.

The palmar wound was closed and the small pieces of bone were removed. The infection gradually cleared up. In the meantime, the fingers were mobilized as much as possible. A roentgenogram showed that the articular surface of the metacarpal remained in the metacarpophalangeal joint. Therefore, after the wound had healed, a bone graft was removed from the ilium for insertion into the hand. All scar tissue was excised as widely as nerves and vessels would allow and the graft was pushed up under the cartilaginous cap. A pin fastened the cartilaginous cap onto the graft and the graft onto the carpal bone. A tendon, wrapped in fascia from around the knee, was grafted into place. Immediate motion was started. No external fixation was used.

The patient did very well and returned to work in three months as a mechanic. Surprisingly enough, he regained full metacarpophalangeal motion, but he still has some residual stiffness of the interphalangeal joints of the fingers. As a result, while he is able to touch the base of his palm with his fingers, he cannot approximate the fingers to their own bases. There is excellent strength in the hand and the patient has lost no time from work in the ensuing three years.

COMMENT

One cannot discuss all of the problems which may arise in pinning of the hand. However, among the more obvious is the use of local anaesthesia. If novocain is used, it must never be injected into the fracture site at a closed reduction. Otherwise it is almost impossible to tell whether or not the fracture is being reduced. Novocain should always be instilled proximally so that the surgeon can get a better idea of the alignment of the fragments and the position of the pin.

Since free use of the hand and fingers is encouraged, the cotton and collodion over the end of the pin may occasionally work loose. The patient has been previously instructed not to touch this but to return as soon as possible for application of more collodion. This has not been a great problem.

Removal of the pin does not present any problem. If the pin is rotated before an attempt is made to remove it, it becomes loose and removal is painless.

In three patients a little weeping developed about the pin, which necessitated the application of a dressing. In one patient, in the third week, the finger became swollen and red. Antibiotics were given for five days; but the pin was left in place and the redness and swelling subsided. The patient did not experience any further difficulty. There have been no definite infections and in no case has the pin hole remained open for more than twenty-four hours after the removal of the pin.

Many hand surgeons use multiple buried wires for the fixation of bone grafts or fragments, sometimes for cases in which intramedullary fixation cannot be used. It is felt that the method herein described has many advantages since no second operation is needed for pin removal and since greater mobility of the hand is allowed.

While pinning is often quite simple, it is definitely not an accident-room procedure. It should only be attempted under good operating-room conditions.

In résumé, there are many satisfactory methods of treating pathological conditions of the hand and fingers. Intramedullary pinning provides adequate fixation for selected fractures and reconstructive surgery and permits the usual rate of healing. Its great advantage lies in the preservation of function and in the reduction in the cost of treatment and loss of income. Approximately forty patients have been operated upon and the results have been satisfactory. Particularly impressive is the complete lack of any need for rehabilitation of the hand or fingers.

1. Pratt, Donald: Internal Splint for Closed and Open Treatment of Injuries of the Extensor Tendon at the Distal Joint of the Finger. J. Bone and Joint Surg., **34-A**: 785-788, Oct. 1952.

DISCUSSION

Dr. J. William Littler, New York, N. Y.: The use of Kirschner wires in reconstructive hand surgery has a wide field of application. Fixation of the grafts in joints is readily gained by the application of these wires. In other cases small pins or wires are excellent in arthrodesis. More perfect mobilization can be obtained through intramedullary fixation. One is encouraged in the use of such radical fixation because of the grave necessity of maintaining the architecture of the hand in its perfect form—that is, with respect to the metacarpals and phalanges—so that there will be no blocking fingers which will not cross.

There is an essential place for the use of Kirschner-wire traction. I see no reason why we should want to use wires for fixation of the fracture itself in cases in which treatment has been delayed. With respect to fractures, when using wire fixation, why not insert the wire at a right angle to the fracture? There are many ways of accomplishing this, but I will not go into the technique of such procedures.

When direct grafts are used, Kirschner-wire reduction leads to minimum contraction of the hand.

I have nothing further to say about this paper. I think we are all more and more impressed by what can be gained by the simplification of methods and certainly this together with the splint of Dr. Mason, Dr. Koch, and Dr. Allen should form a good armamentarium for the treatment of fractures of the fingers and hands.

Dr. William Metcalf, New York, N. Y.: Until very recently it was axiomatic and perhaps even dogmatic teaching that the joints immediately above and below a fracture must be immobilized until the fracture had healed. The resulting well healed fracture was in many instances accompanied by severe stiffness of the immobilized joints and by muscle atrophy and imbalance. This disability was often greater and more prolonged than that of the fracture itself. This led to the development of other forms of fracture fixation: mobile traction, external-bar fixation, and intramedullary fixation. These, while immobilizing the fracture, nevertheless allow a wide range of active motion of the joints proximal and distal to the fracture, and prevent stiffness and atrophy.

In presenting this series of fractures in the hand, treated by intramedullary fixation, Dr. vom Saal has reemphasized certain principles in fracture healing—correct apposition of surfaces, prevention of motion at the fracture site, and maintenance of proper position.

Equally important, he has placed particular stress upon the immediate mobilization of the joints to either side of the fracture and of all the other joints of the hand made possible by intramedullary pinning. This results in the maintenance and the stimulation of vascular and lymphatic functions and, therefore, in the early resorption of the serofibrinous exudate, which otherwise would become organized and would cause chronic induration and fixation of the soft-tissue gliding components. Muscle atrophy and bone decalcification are also prevented by the improved physiological function incidental to early mechanical function.

Most important of all, Dr. vom Saal demonstrates the feasibility of the very early return to work of the injured person, often within a few days of his accident. This gives the patient active, highly motivated, and purposeful exercise in well established and integrated patterns and in accustomed surroundings. This contrasts spectacularly with the slow return of function and the great inertia against return to work in the patient with a complete and lengthy period of immobilization. The motivation of the patient's job cannot be replaced by the weekly or biweekly exhortation of the physician or the kindly laying on of hands by the physiotherapist. The economic and social advantages to the patient, the saving of the physician's time, and the saving of the insurance-carrier's money are obvious to us all.

Before closing, a few minor variations in the technique demonstrated should be noted.

The use of two wires in different axes and in different planes to each other gives greater stability, prevents axial rotation, and prevents distraction of the two fragments.

The wire ends may be kept subcutaneous. If a short right-angle bend is made at the cut-off end of the wire, the wires are later easily located and removed through a short incision, one to two centimeters long.

(*Continued on page 87*)

THE IMPORTANCE OF DIRECT SURGICAL ATTACK UPON LESIONS OF THE VERTEBRAL BODIES, PARTICULARLY IN POTT'S DISEASE*

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WAYNE O. SOUTHWICK, M.D., BALTIMORE, MARYLAND

From the Department of Surgery, Division of Orthopaedic Surgery, The Johns Hopkins Hospital and The Johns Hopkins School of Medicine, Baltimore

Since the opening of The Johns Hopkins Hospital in 1889, 858 patients have been admitted to the Hospital for orthopaedic treatment with the diagnosis of tuberculosis of the spine. This paper concerns itself with the 407 patients who have been admitted in the past twenty-five years (1926 to 1951) either with the diagnosis of tuberculosis of the spine or with some other diagnosis which was later changed to tuberculosis of the spine. A survey of the earlier cases proved unprofitable, as many of the modern methods of diagnosis and treatment were not then in use, and a number of the patients were treated in the Out-Patient Clinic without admission to the Hospital.

This study was undertaken to determine the place of direct surgical procedures in the diagnosis of spine lesions, to examine the results of such procedures in the treatment of tuberculous spondylitis and paraplegia, and to evaluate the use of antibiotic agents in the prevention of complications following such procedures. The importance of immobilization, spine fusion, general medical management, and other accepted factors in the treatment of tuberculosis is not under discussion.

HISTORICAL BACKGROUND

In 1779 Percivall Pott wrote his classical paper entitled "Remarks on That Kind of Palsy of the Lower Limbs Which Is Frequently Found to Accompany a Curvature of the Spine and Is Supposed to Be Caused by It. Together with Its Method of Cure". In this work he advocated surgical drainage of associated abscesses as "the method of cure" of paraplegia, and he referred to the observations of Hippocrates on the benefit from drainage in similar cases.

In 1892 Ménard[15,16] in France inadvertently opened a paraspinal abscess while performing a thoracic laminectomy for paraplegia. There was dramatic postoperative return of function; this led him to perform a series of successful costotransversectomies which he reported in 1894. During the same period favorable results from direct attack upon the spine lesion were published by Vincent in France in 1882, Clarke in England in 1903, and Wassiliew in Poland in 1908.

The procedure soon fell into disfavor, because of the excessive mortality rate from secondary bacterial infection and dissemination of tuberculosis. Ely in 1911 quoted Calot as saying, "to open an abscess from a tuberculous spine, or to permit it to burst, is to open a door through which death almost always enters". Elsberg in 1916 suggested that operative treatment should be performed only after conservative treatment had failed.

In 1931 and in subsequent articles Girdlestone[7,8] restored interest in direct surgical attack by demonstrating that costotransversectomy was not unduly hazardous if accompanied by meticulous aseptic technique, and that it was more effective than conservative or indirect operative treatment for tuberculous paraplegia.

In the American literature on Pott's disease many orthopaedic surgeons have discussed the difficulties of diagnosis of lesions of the spine[13,14,18,22], while the role of direct operations has seldom been emphasized[3,12]. Most studies have been centered upon modifi-

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 30, 1952.

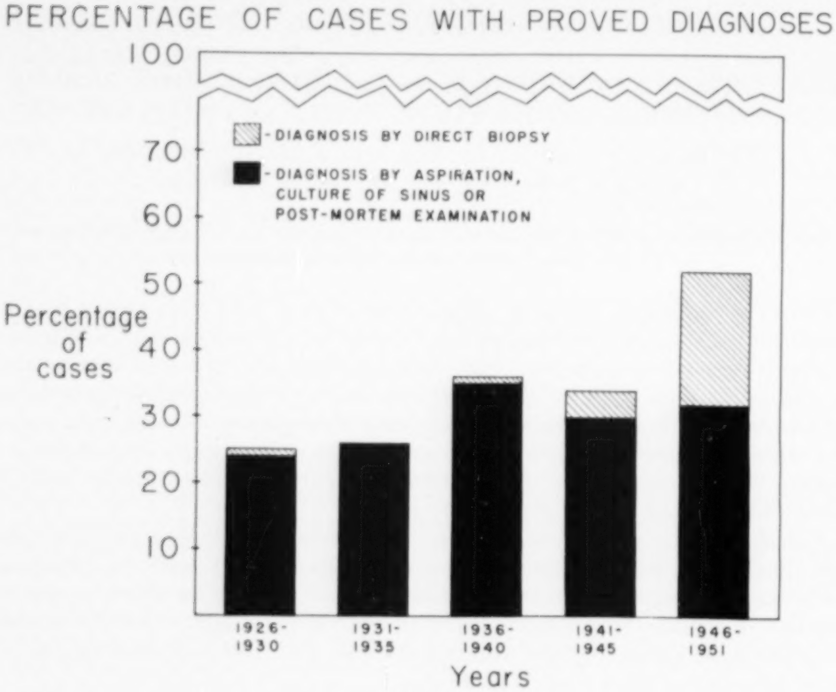

CHART I

cations of the methods of securing immobilization of the spine as originally described by Hibbs and Albee.

In 1940 Swett, Bennett, and Street observed that a persistent paraspinal abscess was accompanied by delayed healing of the lesion in the spine. Until recent times, however, the drainage of tuberculous abscesses has been avoided. In discussing the use of streptomycin, Bosworth and others have of late advocated the evacuation of massive collections of tuberculous débris as a means of securing more rapid healing of the disease.

At The Johns Hopkins Hospital there has been a rather striking change in the rationale of treatment of spine lesions during the past five years. Direct operations are now performed both for diagnosis and for the effect upon the lesion itself. The development of new therapeutic agents for many infectious, neoplastic, and degenerative diseases has been accompanied by an increasing need for establishing the exact etiological diagnosis of spine lesions. Another reason for considering direct operative biopsy a necessity is the widely accepted clinical observation that antibiotic agents can produce optimal effect in the early stages of infection and that less effect results from administration after extensive destruction of tissue and alteration of blood supply has occurred.

Under this new plan of management the first cautious ventures into direct surgical attack were made. Abscesses were evacuated, streptomycin was administered locally and parenterally, and a gratifying response in the clinical course of tuberculous spine disease was observed. In addition there also appeared a surprising number of cases in which the operation led to a complete change in the initial diagnosis and therefore in treatment.

MATERIAL FOR STUDY

The cases under consideration consist of 407 consecutive patients admitted to the Hospital for treatment of tuberculous spondylitis, or patients admitted with a diagnosis of some other condition which subsequently proved to be tuberculous spondylitis.

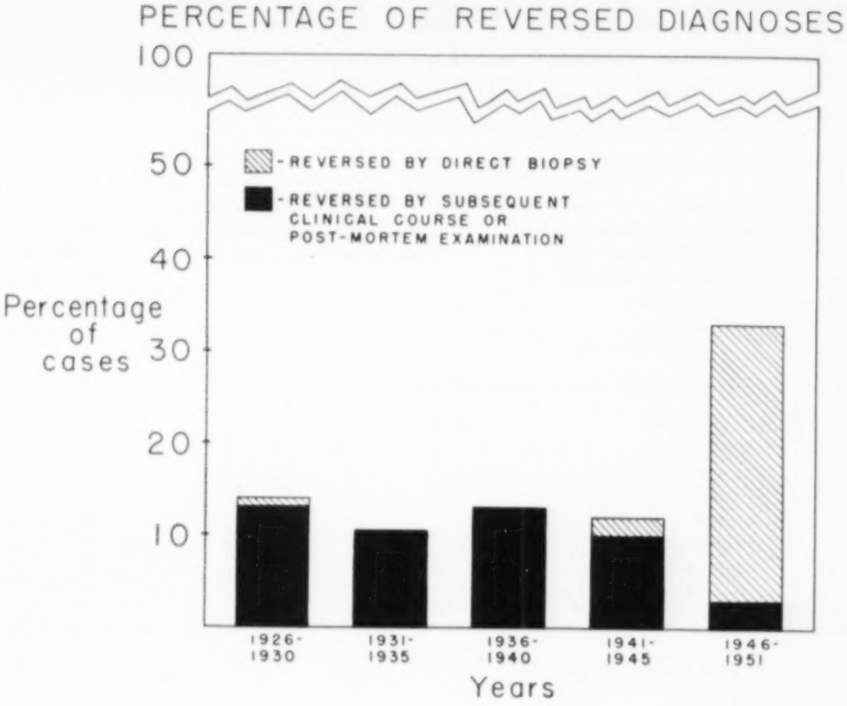

CHART II

The findings of this investigation have been reduced to charts for clarity and brevity.

Proof of Diagnosis

Chart I shows the percentage of cases with proved diagnosis and indicates the method by which the diagnosis was proved. The cases have been grouped according to five-year periods. One or more of the following methods have been considered essential in establishing an unequivocal diagnosis: positive laboratory culture of the organism, positive guinea-pig inoculation, or characteristic histopathology. Positive diagnoses were found in a uniform average of 30 per cent. of the cases by all non-operative means, while the recent policy of direct surgical attack upon the lesions has added another 22 per cent.

Reversals of Diagnosis

Chart II deals with those cases in which there was an error or delay in diagnosis and the manner in which the error became apparent. The diagnosis has been considered "reversed" if a change was necessitated by the eventual course of the disease, by post-mortem examination, or by the findings of direct biopsy. In the cases in which a direct vertebral biopsy was done, the diagnosis listed in the clinical record as the most probable or first-choice diagnosis was taken as the preoperative diagnosis.

Sixty-eight cases were found in which there was an error in initial diagnosis; these cases have been divided into five-year groups from 1926 to 1951. There was found an average error of 12 per cent. during the first twenty years among 320 patients, the reversal or correction of diagnosis being made almost entirely at autopsy or late in the course of the disease. In the most recent period one-third of the group of eighty-seven patients have had a reversal of initial diagnosis, twenty-six of twenty-nine such corrections being obtained from biopsy of the lesion by direct surgical attack.

TABLE I

ERRORS IN DIAGNOSIS (SIXTY-EIGHT CASES)

Error Demonstrated by Eventual Clinical Course or Autopsy		
Initial erroneous diagnosis of tuberculous spondylitis		8 cases
Final Diagnosis:		
Carcinoma, metastasis from breast, thyroid, and unknown site	3	
Multiple myeloma	1	
Malignant chordoma	1	
Medulloblastoma	1	
Osteomalacia	1	
Not a disease of spine	1	
Initial failure to recognize tuberculous spondylitis		31 cases
Original Diagnosis:		
Tumor	7	
Fracture	7	
Osteomyelitis, bacterial	3	
Arthritis	4	
Congenital abnormality	4	
Not a disease of spine	6	
Final Diagnosis: Tuberculous spondylitis		
Error Demonstrated by Direct Operation		
Initial erroneous diagnosis of tuberculous spondylitis		8 cases
Final Diagnosis:		
Hodgkin's disease	1	
Giant-cell tumor	2	
Multiple myeloma	1	
Osteomyelitis, staphylococcal	2	
Fracture	1	
Aneurysm, abdominal aorta	1	
Initial failure to recognize tuberculous spondylitis		21 cases
Original Diagnosis:		
Spinal-cord tumor	1	
Chordoma	1	
Leukaemia	1	
Mediastinal tumor	1	
Sarcoid	1	
Syphilis	2	
Blastomycosis	1	
Carcinoma, metastasis from prostate, ovary, or unknown site	5	
Hodgkin's disease	2	
Osteomyelitis, staphylococcal	2	
Herniated disc	3	
Aneurysm, abdominal aorta	1	
Final Diagnosis: Tuberculous spondylitis		

The most significant explanations for the apparent recent increase in clinical diagnostic error are that (1) biopsy is now being performed as an integral part of diagnosis of vertebral lesions in their early stages, when exact roentgenographic diagnosis is most difficult, and that (2) there were undoubtedly more diagnostic errors in the earlier years than is apparent from the available clinical records. Case records with inadequate data were assumed to have had no change in diagnosis, although the initial diagnosis may never have been fully proved.

TABLE II

DEATHS OR COMPLICATIONS FOLLOWING SURGICAL PROCEDURES FOR TUBERCULOUS SPONDYLITIS

Complication or Death	1926 to 1947 149 Operations without Administration of Streptomycin	1948 to 1951 78 Operations with Administration of Streptomycin
Death, including miliary and meningeal spread	9	0
Dissemination to bone, tendon, peritoneum, or genito-urinary tract	8	0
Pulmonary Reactivation	1	0

TABLE III

PERSISTENT DRAINING SINUS

	1926 to 1947 Treatment without Streptomycin	1948 to 1951 Treatment with Streptomycin
Following Operations for Abscess Drainage	14 (66 operations)	3 (16 operations)
Following Direct Vertebral Biopsy	1 (3 operations)	0 (24 operations)

Analysis of Sixty-eight Cases with Initial Diagnostic Error

Table I demonstrates the types of disease which gave rise to diagnostic error in sixty-eight of the 407 cases in this study. Distinction is made between cases in which the error was recognized late in the course of treatment (or at postmortem examination), and the cases in which error was corrected without delay by direct operation.

Eight lesions which had been diagnosed as tuberculous spondylitis were eventually proved to be non-tuberculous. Thirty-one patients had been initially considered to have some other condition (including tumor, fracture, infection, arthritis, congenital abnormality, or a condition which was not a spine lesion), but after varying periods of delay, tuberculous spondylitis was established as the correct diagnosis.

The contribution of direct operation toward obtaining early, unequivocal diagnosis is established by the cases to be discussed. There were eight patients in whom all preoperative evidence had pointed to tuberculous spondylitis, but at operation Hodgkin's disease, giant-cell tumor, multiple myeloma, osteomyelitis, fracture, or aortic aneurysm was found. An additional twenty-one patients had been initially considered to have had adequate clinical and roentgenographic findings for diagnosis of the wide variety of diseases shown in Table I, but at direct operation the presence of tuberculous spondylitis was demonstrated.

Complications following Surgical Procedures for Tuberculous Spondylitis

Table II analyzes the deaths or complications following surgical procedures for tuberculous spondylitis. Dissemination of tuberculosis and pulmonary reactivation occurring within a period of one year after operation have been considered as complications.

These cases are divided into two groups, one in which operation was performed *without* the protection of streptomycin, the other in which operation was performed *with* the protection of streptomycin, corresponding approximately to the periods 1926 to 1947

TABLE IV

Tuberculous Paraplegia Improved under Treatment

Total Number of Cases: Seventy-nine

		Early-Type Paraplegia		Late-Type Paraplegia	
Method of Treatment	Total No. of Cases	No. of Patients Treated	No. of Patients Improved	No. of Patients Treated	No. of Patients Improved
Conservative Treatment	59 (Inadequate data in 16 cases)	21	8	22	4
Laminectomy	13	7	1	6	0
Direct Operation	7	4	4	3	1

and 1948 to 1951 respectively. There is a marked contrast between results in the group treated before the advent of streptomycin, in which there were nine deaths, eight disseminations, and one pulmonary reactivation, and in the streptomycin-treated group, in which to date none of these complications have appeared.

Table III lists separately the incidence of draining sinus tracts following operations for drainage of a migratory abscess and direct surgical attack upon vertebral lesions. A comparison of the cases in the pre-streptomycin group with the more recent cases suggests that postoperative drainage has not been entirely controlled by antibiotic therapy. Before streptomycin became available drainage persisted in fourteen cases following the evacuation of sixty-six tuberculous abscesses. In the streptomycin-treated group sixteen similar operations have resulted in three persistent sinuses.

A more favorable result of combined antibiotic and surgical treatment is found in the group of cases where direct vertebral biopsy was performed. In one of three patients in whom a vertebral biopsy was done without streptomycin, a persistent sinus tract developed, while direct operation into the tuberculous focus in twenty-four cases of the streptomycin-treated group has not produced a draining sinus.

From recent experience it may be stated that persistent drainage is not regarded with the same apprehension today as in the pre-antibiotic era. It is our impression that the progress of the disease is best handled by drainage combined with antibiotic therapy, but this must await the accumulation of greater numbers of cases for proper evaluation.

Surgical Treatment of Tuberculous Paraplegia

Table IV shows the number of cases of tuberculous paraplegia which have improved with treatment. The seventy-nine cases which have appeared during the past twenty-five years have been divided for study into three groups according to the type of treatment: conservative treatment, laminectomy, and direct operation into the spine lesion. Paraplegia which accompanied the initial course of active spondylitis is considered early, while paraplegia appearing after the original spondylitis had become quiescent is rated as late.

With conservative treatment there was improvement in 28 per cent. of those forty-three patients with adequate follow-up, improvement being noted twice as frequently in the patients with early-type paraplegia as in those with late paraplegia.

In the group of thirteen patients who had laminectomies performed for paraplegia, only one patient with early-type paraplegia improved. In this single patient, the paraspinal abscess was inadvertently entered during the operation, once more confirming the clinical observations which date from the times of Hippocrates, Pott, and Ménard.

Following direct operative decompression and streptomycin therapy, four patients with early-type paraplegia all showed prompt improvement, while one of three patients with the late type also improved.

The number of patients operated upon for tuberculous paraplegia is too small to support statistical analysis, but the results of direct surgery to date show an apparent advantage over conservative treatment or laminectomy, and we are encouraged to advocate direct operation as the treatment of choice.

SUMMARY AND CONCLUSIONS

From a study of 407 patients admitted to The Johns Hopkins Hospital either with the diagnosis of tuberculosis of the spine or with some other diagnosis which was changed to tuberculosis of the spine during the years 1926 to 1951, it has been observed:

1. Proved diagnosis was obtained by non-operative means in an average of 30 per cent. of the entire series (407 cases). Direct vertebral biopsy has been responsible for an increase to 52 per cent. of proved diagnosis in the eighty-seven cases which occurred during the past five years.
2. Erroneous diagnosis was found in 12 per cent. of the 320 cases occurring during the first twenty years. Direct vertebral biopsy has reversed the initial diagnosis in twenty-six out of eighty-seven cases occurring during the past five years.
3. The difficulty of making exact diagnosis of lesions of the vertebral bodies by clinical and roentgenographic study alone is demonstrated by the sixty-eight cases in which there was an initial diagnostic error. Fifty-two of the sixty-eight errors arose from failure to recognize tuberculous spondylitis; sixteen of the sixty-eight errors arose from making the diagnosis of tuberculous spondylitis without laboratory or biopsy confirmation.
4. In twenty-four consecutive cases, direct operation into tuberculous lesions of the spine, combined with local and parenteral administration of streptomycin, has proved a safe and satisfactory diagnostic procedure.
5. Direct operative approach and evacuation of the paravertebral abscess appears to be the treatment of choice in tuberculous paraplegia.

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DISCUSSION

Dr. Philip H. Moore, Mt. Edgecombe, Alaska (by invitation): There are three points stressed by the authors which seem especially important. First is their plea for direct biopsies. This procedure increased their percentage of positive diagnoses from 30 per cent. to 52 per cent., an important step forward. I see no reason why all of us should not subscribe to this procedure provided that proper judgment and proper technique are used.

A second point of much interest pertains to direct surgical attack of tuberculous spondylitis with paraplegia. In our series of 139 cases studied in the last four years—that is, cases without paraplegia—we found roentgenographic evidence of paravertebral abscesses in 54 per cent. of all spine lesions. It is my belief that this percentage would be much higher if our roentgenograms were reviewed and if particular attention were given to linear paraspinal shadows. Paraplegia, or other evidence of spinal-cord pressure, was present in sixteen cases, or about 12 per cent. of our series. In four of our sixteen cases the paraplegia persisted under conservative treatment. In three patients subjected to anterior decompression, we found abscesses causing pressure. All three of the operations have been successful and there were no deaths. The three patients operated upon were all young and this may account for the lesion encountered, that is, an abscess.

We agree with the authors that laminectomy is a questionable procedure, and that an anterior or anterolateral attack is to be favored unless the primary lesion is in the lamina. I have never seen such a lesion. The anterolateral approach, as advocated by the authors, not only gives a better chance to relieve the paraplegia, but allows for a more adequate removal of diseased tissue. Aside from the relief of paraplegia, there is a marked improvement in the general condition of the patient following the removal of abscesses and tissues destroyed by tuberculosis of the bones and joints. I have personally observed this result in cases of abscess removal by Dr. Hatcher and Dr. Bosworth, as well as in our own cases. Wide removal of, instead of incision into, tuberculous abscesses, the use of antibiotic drugs, and careful surgical asepsis, as stated by the authors, have changed the old view. We have observed the successful primary closures of many of these fields and subsequent healing of wounds too large to close at the time of surgery. This is the rule rather than the exception. Not a single case of postoperative dissemination of the disease has been observed in our series, although in every case a radical surgical procedure was undertaken. The occasional postoperative sinuses have closed and have remained closed with adequate—and I want to stress that word adequate—streptomycin treatment. Too many surgeons are giving too little over too short a period of time.

Furthermore, if we accept the idea that immobilization of the diseased spine by surgical fusion is desirable in arresting tuberculous spondylitis, it would seem inadvisable to perform a laminectomy which removes a good portion of the foundation for such a fusion.

What is the role of streptomycin and para-aminosalicylic acid? Although we have studied ninety control cases, we do not have all the answers. In a recent symposium [a–d] the authors were largely in agreement on the use of streptomycin. It is not a cure for tuberculosis of the bones and joints; it does seem to result in marked improvement in the general condition of a large percentage of patients; its use hastens the closure of sinuses and perhaps makes early and more extensive surgery possible.

In our Orthopaedic Section of the Medical Center we are treating patients with bone and joint tuberculosis who display no evidence of active pulmonary disease. We are also now treating about forty-five patients who have active pulmonary lesions in addition to the tuberculosis of the bones and joints; when these patients are subjected to procedures similar to the ones reported by the authors there seems to be no evidence that the expected course of the pulmonary lesions has been adversely influenced. On the contrary, any procedure favoring the arrest of the skeletal lesions seems to aid the patient's recovery from the pulmonary tuberculosis. Our experience leads me to agree with the conclusion of the authors of this most excellent paper.

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Dr. F. P. Dewar, Toronto, Ontario, Canada: The authors' paper is divided into three parts. The first portion—namely, the importance of direct surgical procedures in the diagnosis of spine lesions—takes precedence in the arrangement of their paper, and to my mind, also in the message that it carries to this audience. The authors' careful follow-up of 407 cases of spinal disease has shown errors in diagnosis arrived at by non-operative means in sixty-eight cases, or 16 per cent. In addition, they submit that this figure is probably low in the light of findings of the past five years, when direct approach has produced a high percentage of reversal of diagnosis. It would seem probable that many incorrectly diagnosed cases lie buried in the files. The errors embrace the whole gamut of lesions occurring in the spine. When in a great center of learning eminent physicians are the authors of these erroneous diagnoses, we know that our clinical methods must be exhausted and unreliable in many instances. This, then, is the keynote of the paper: recognition of the fact that the history, x-rays, physical findings, tuberculin tests, sedimentation rate, and occasional aspiration of an abscess still leave us with many diagnoses based only on circumstantial evidence. The authors have, in addition, proved that a more direct surgical approach will, to a great extent, fill the need for a more certain conclusion in this type of lesion.

The direct surgical approach was not described by the authors and is assumed to mean a costotransversectomy in the thoracic portion of the spine and a more formidable extraperitoneal approach in the lumbar area. One must assume that they have attempted to use the more simple procedure of vertebral biopsy punch which is popular in many centers. This method has in most instances been satisfactory to us and has frequently saved us from operating upon a patient with secondary carcinoma. Only when such a biopsy fails, which is seldom, is it necessary to revert to a more direct attack. The principle of recognizing our clinical weakness and of using more direct methods to obtain a correct diagnosis is most commendable, but the means should be the most simple that we can devise. I would like to ask the authors why they have discarded the use of the vertebral biopsy punch.

The second portion of the paper is devoted to the value of streptomycin in preventing complications during operations in a tuberculous field. The authors' experience reflects the general feeling about streptomycin among those of us treating tuberculous lesions. It has undoubtedly made surgical procedures in the presence of tubercle bacilli infinitely safer. This is an important clinical observation which has been borne out by the experience of ourselves and others, and which will undoubtedly influence in the future our ideas regarding a more direct attack upon tuberculous lesions, particularly cold abscesses. The authors mentioned the clinical improvement noticed in their patients upon drainage of a cold abscess and paraspinal abscess, but they did not discuss this in detail. I wish they would tell us more about what improvement has been noticed and how they evaluated that improvement, because to my mind it is very difficult to ascertain just how rapidly a patient with tuberculous spondylitis is improving. It takes months and years of watching to determine the course with certainty.

Finally, the authors have discussed seven cases of Pott's paraplegia treated by drainage of the abscess. As they have stated, this number is insufficient to support any statistical or clinical analysis. They are giving a clinical impression. They are to be commended for their progressive thinking and this meeting anticipates hearing from them in the future.

Dr. Johnson (closing): I want to say that all the hard work, the great chore of investigating these cases, was carried out by the junior authors and that is the reason that Dr. Hillman was asked to present the paper. I have stood behind them and am therefore speaking for them now. I am gratified by the kind remarks of both discussors and the almost blanket approval that Dr. Moore has given on the basis of his wide experience in Alaska. I may say that our cases probably differ to a considerable extent from his, so that we thus have double confirmation. Our patients were practically all adults, because children coming into The Johns Hopkins Clinic during this period were sent to the Children's Hospital School and so are not included in our series. A few of them were hospitalized at Hopkins, but only rarely. I may say also in that connection that I have seen my first case of laminar tuberculosis with paraplegia. The child is now in the Hospital recovering, but she gave us a very difficult diagnostic and surgical problem to deal with. This condition, therefore, occurred in the ratio of 1 to over 400.

(*Continued on page 114*)

OSTEOCHONDRITIS DISSECANS IN CHILDREN *

BY WILLIAM T. GREEN, M.D., AND HENRY H. BANKS, M.D.,
BOSTON, MASSACHUSETTS

*From the Department of Orthopaedic Surgery, Harvard Medical School,
and The Children's Medical Center, Boston*

Loose bodies in joints, and osteochondritis dissecans in particular, have occupied the interest of many of our distinguished forebears ever since Ambroise Paré described the removal of a loose body from a joint in 1558. König, in 1888, gave the condition the name "osteochondritis dissecans" and is often credited with the original description. However, Sir James Paget had described the process in some detail eighteen years before this and had given to it the name "quiet necrosis".

TABLE I

NUMBER OF PATIENTS WITH OSTEOCHONDRITIS DISSECANS SEEN AT THE CHILDREN'S HOSPITAL
1939–1952

Number of patients (20 male, 7 female)	27
Age at onset of symptoms (17 were under 12 years)	4 to 15 years
Number of joints involved (32 knees, 3 elbows, 1 ankle)	36
Patients with multiple lesions	8

The process has been described as occurring mainly in the young adult. The treatment most frequently recommended is excision of the involved area and removal of any loose bodies from the joints [3, 6, 14, 17, 27, 31]. A few reports discuss the advisability of non-operative observation in instances in which no free body can be demonstrated [14, 18]. Reference to the lesion in children is decidedly uncommon in the literature. We have been able to find only nine such cases reported, two in the hip and seven in the knee [1, 7, 8, 9, 10, 28, 33, 34]. Except for Strange's case, in a boy four and a half years old, no patient was under nine years of age.

It is the purpose of this paper to record our experience with a series of twenty-seven cases, all of which occurred in children under fifteen years of age; in nineteen of these the treatment was by non-operative means. All of the patients were seen at The Children's Hospital, Boston, in the last twelve years. Particular emphasis will be given to a discussion of the natural history of the condition and the results which were obtained from the various types of treatment.

INCIDENCE

The ages of the twenty-seven patients in this series ranged from four to fifteen years; seventeen were under twelve years and six were under nine years of age (Table I). In sex incidence, there was a ratio of three to one favoring the male, which is the proportion ordinarily seen in older patients [3, 14, 17, 27, 31]. There were thirty-six joints involved, of which there were thirty-two knees, three elbows, and one ankle. Eight of the patients had lesions in more than one joint. In most instances, the multiple lesions were symmetrical in distribution; this was particularly evident in the knee where eight of the twenty-four patients had bilateral symmetrical lesions. The medial femoral condyle was the site most

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1952.

TABLE II

SITE OF LESIONS IN THIRTY-TWO KNEES
(Twenty-four Patients)

	Unilateral	Bilateral	Total
Medial femoral condyle	13	5	18
Lateral femoral condyle	2	1	3
Medial and lateral condyles		2	2
Patella	1		1
Total	16	8	24

commonly affected. This was seen in eighteen patients in whom thirteen lesions were unilateral and five were bilateral (Table II). The lateral femoral condyle was affected in three patients, of whom one presented bilateral lesions. Two patients had lesions in the medial and lateral condyles of both knees; in one, the patella was affected. One patient, in addition to the symmetrical knee lesions (Fig. 4-A), had a typical osteochondritis dissecans of the elbow (Fig. 4-D) and osteochondritis involving several vertebrae (Fig. 4-C).

The patients with osteochondritis dissecans, furthermore, showed a surprisingly high incidence of osteochondritis of the ordinary type in other areas. Six patients presented such osteochondritic lesions. Three of these showed so-called Osgood-Schlatter disease; there was one instance of osteochondritis of the lower pole of the patella, to which the name Larsen-Johansson [13, 26] has been applied; and two patients exhibited extensive osteochondritis of the spine, involving many vertebrae. One patient who had a lesion of the medial condyle of each femur had a discoid lateral meniscus bilaterally.

CLINICAL DATA

Most of the patients, twenty-one of the twenty-seven, had a presenting complaint of intermittent joint disability of mild degree. In four the onset was acute, and in two the lesions were asymptomatic. In those who had chronic intermittent symptoms referable to the knee, a variable history of recurrent pain was the rule. Soreness, stiffness, particularly on first movements, giving way, clicking, and occasional swelling, which was interpreted as joint effusion, were some of the other more common complaints. In the four patients in whom the onset was acute, the symptoms developed relatively suddenly with painful, limited motion and joint effusion. This was the usual history in those in whom there was a free body which had been extruded into the joint; three of the four patients presented such a finding. Locking was a complaint in only two cases. Only eight of the twenty-seven patients gave a history of trauma which they felt might be associated with the onset of their difficulty.

Physical signs were not specific at the time of examination in the majority of those in whom the symptoms were intermittent and of long duration. Atrophy of the controlling muscles was the most common abnormal finding. Local tenderness was present in about one third of the cases. In the knee, this could best be obtained by pressure on the affected femoral condyle with the knee flexed. Limp, excess fluid, and limited motion were common findings in the small number who had relatively severe symptoms. In one half of the patients, no physical findings suggesting abnormalities were recorded at the time of the examination.

Roentgenograms

While the diagnosis of osteochondritis may be suspected from the clinical history and physical findings, it can ordinarily be confirmed only by roentgenograms. The lesions in

TABLE III
NON-OPERATIVE TREATMENT

Type of Protection	Average Time Protected (*Months*)	Average Time of Healing (As Shown by X-Ray)		
		Early Filling-in (*Months*)	Lesion Barely Seen (*Months*)	Joint Normal by X-Ray (*Months*)
Patten-bottom splint	7 (5)	3	7	11
Walking cylinder	4	3	6	10

the child present a crater-like area of rarefaction affecting the articular subchondral bone, just as they do in the adult. In more than half of the cases in this series, these crater-like lesions contained fragments resembling loose bodies or sequestra (Figs. 3-A and 3-B). In 75 per cent. of the knees, the medial femoral condyle was involved in its lateral portion, with the process often extending to the margin of the intercondylar fossa adjacent to the posterior cruciate ligament. The most common location in the anteroposterior plane, as seen in lateral roentgenograms, was just posterior to a line which is made by bisecting the shaft of the femur and the epiphyseal plate. This is about the middle of the distal circumference of the epiphysis and represents the area of weight-bearing when the knee

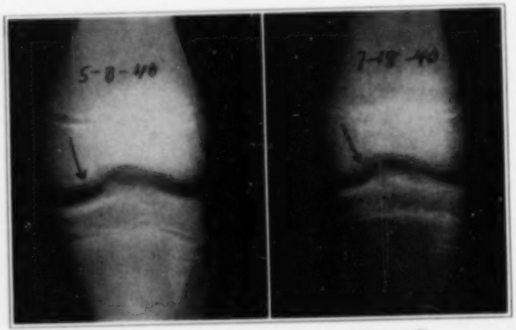


FIG. 1-A FIG. 1-B

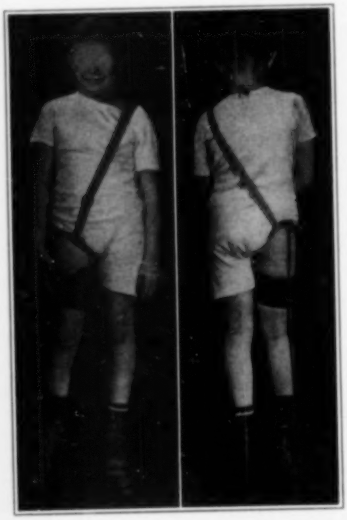


FIG. 1-E

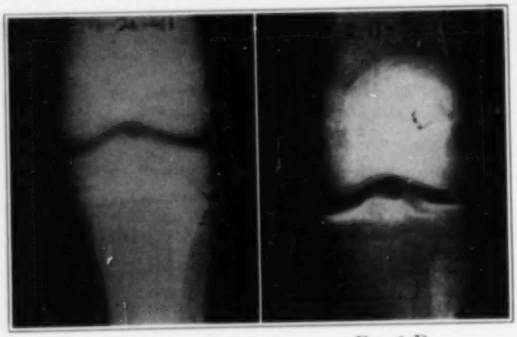


FIG. 1-C FIG. 1-D

Fig. 1-A: Case 1. Roentgenogram showing left medial femoral condyle before exploratory arthrotomy. Note the suggestion of loose-body formation.

Fig. 1-B: Rapid healing within two months of the treatment by protection in patten-bottom brace.

Fig. 1-C: Note almost complete healing within five months.

Fig. 1-D: Roentgenograms made almost ten years after arthrotomy showed normal joint.
Fig. 1-E: Thomas patten-bottom brace protecting right leg; three-inch-high sole on the left shoe.

is extended. The lesion not infrequently was posterior to this position; rarely was it anterior to it.

Visualization of the lesion requires roentgenograms of good quality; and, occasionally, special views are necessary. Most of the lesions were recognized in the ordinary anteroposterior and lateral projections. However, postero-anterior tunnel views should be part of the routine roentgenographic examination. The tunnel view is particularly valuable in visualizing the posterior portion of the condyles and the intercondylar notch (Fig. 3-B).

The most satisfactory tunnel view, in our experience, is obtained by placing the patient prone, flexing the knee to 60 degrees, and then directing the tube in a caudad direction so that the rays intercept the joint at an angle of between 20 degrees and 40 degrees, depending upon how far posteriorly in the condyle one wants to emphasize the visualization. The posterior portion is best seen in the more angular projection; the usual angle is 20 to 30 degrees. The Holmblad view which is a postero-anterior exposure made with the patient in the kneeling position is also a satisfactory tunnel view [12].

Anterior tangential views of the anterior femoral condyle, so-called tangential patellar views, are helpful in visualizing lesions in the anterior portion of the condyle and in the patella. Off-lateral views and oblique projections may be of assistance in visualizing each condyle separately. In only one of our patients was the lesion not recognized or suspected from the roentgenograms, and in this instance only anteroposterior and lateral projections were made; tunnel views were not obtained.

TREATMENT

Our patients may be divided according to treatment into those who were treated without surgery and those who were given operative treatment for their lesions. Twenty-five of the thirty-six joints in our series have been treated without surgery. Nine have been treated by operative attack, including one who had had preliminary protective treatment. Three of the joints were untreated.

Our interest in the non-operative treatment arose from an experience with a patient twelve years ago.

CASE 1. A boy, aged eleven years, was first seen May 6, 1940, with a complaint of inability to straighten his left knee. He had noticed occasional discomfort in this knee on long walks; but, on the day before being seen, he was unable to straighten his left knee after kneeling for fifteen minutes at church. Physical examination revealed flexion deformity of 45 degrees with further flexion to 120 degrees. A further attempt at motion was painful and was protected by muscle spasm. There was some tenderness over the medial condyle of the left femur and there was some slight atrophy of the quadriceps. Roentgenograms showed an area of rarefaction, a central dense area of bone in a crater-like area which was interpreted as osteochondritis dissecans of the left medial femoral condyle (Fig. 1-A).

On May 10 the left knee was explored; the cartilage over the lateral aspects of the medial femoral condyle was found to be intact and of an essentially normal color. It did "give" in the involved area on blunt pressure, but there was no crack in the cartilage. It was obvious that the cartilage lacked normal support in the area which had been visualized in the roentgenograms, but it was also evident that the cartilage was healthy. The joint was therefore closed without any further procedure; the lesion was left intact.

Postoperatively, he was fitted with a patten-bottom non-weight-bearing brace on the affected side and with a shoe with a three-inch raised sole on the other side (Fig. 1-E). This removed all weight from the affected knee. His knee was thus protected for nine months. The roentgenograms showed rapid filling in of the defect, and marked healing occurred in two months (Fig. 1-B). The defect could barely be seen by roentgenograms at the end of five months (Fig. 1-C) and it could not be seen at all at ten months (Fig. 1-D). The patient was examined eight years after treatment. He had remained asymptomatic in the interim. Physical examination was entirely negative and there were no abnormalities seen in the roentgenograms.

Although he was kept in a non-weight-bearing brace for nine months, one suspects from the serial roentgenograms that the brace could have been removed four to five months sooner with just as good results. We were impressed by the rapid healing of the lesion in this boy's knee and became very much interested in the course of such lesions in children under conditions of protection. This series of cases is the result.

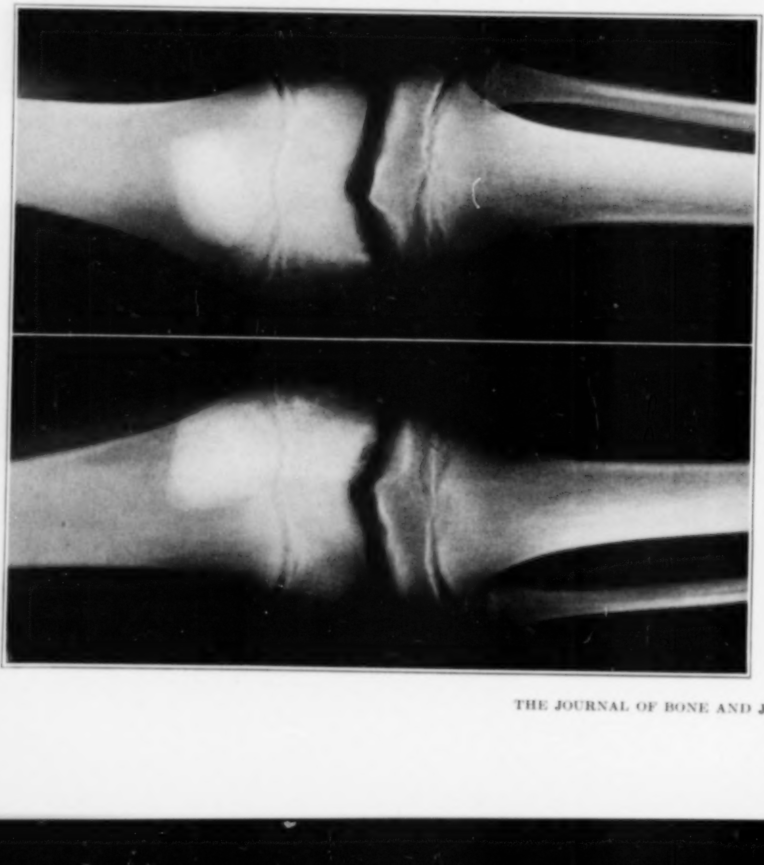


Fig. 2-A

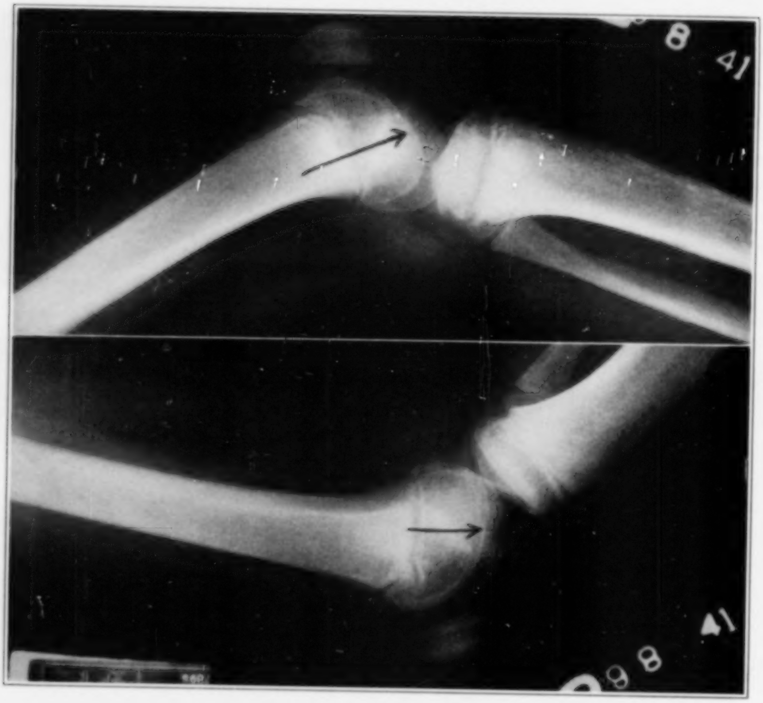


Fig. 2-B

Fig. 2-A: Case 2. Bilateral lesions of medial femoral condyle at onset of treatment.
Fig. 2-B: Lateral views five months later show well outlined lesions in the usual site.

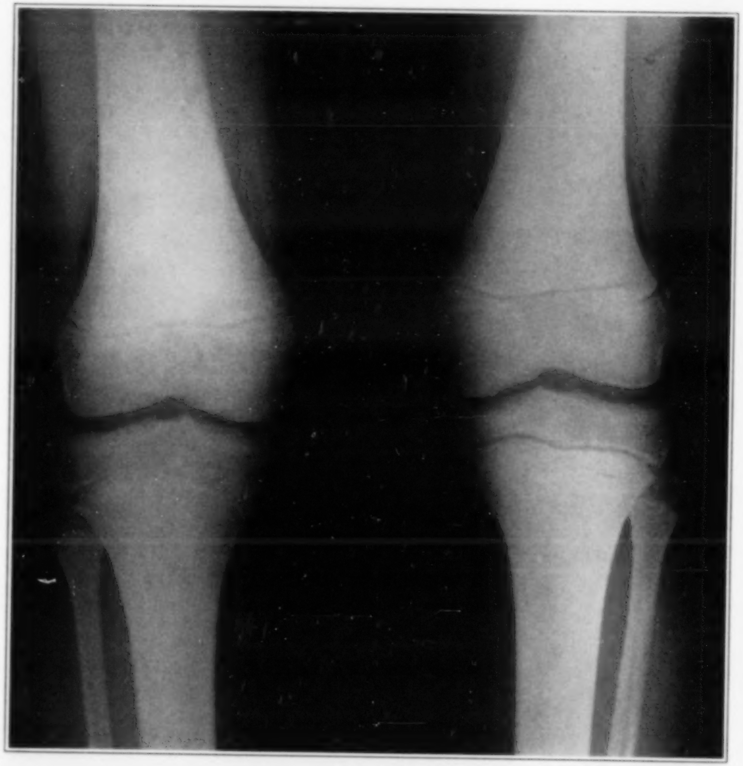
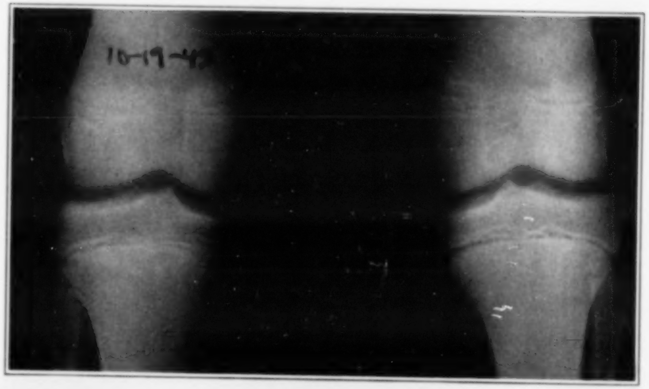


FIG. 2-C

Fig. 2-C: Marked improvement within six months.



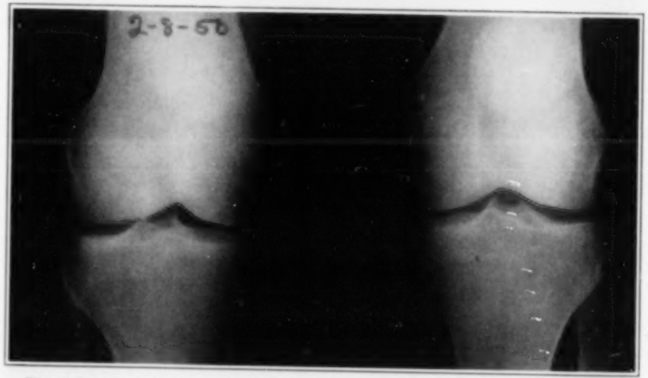
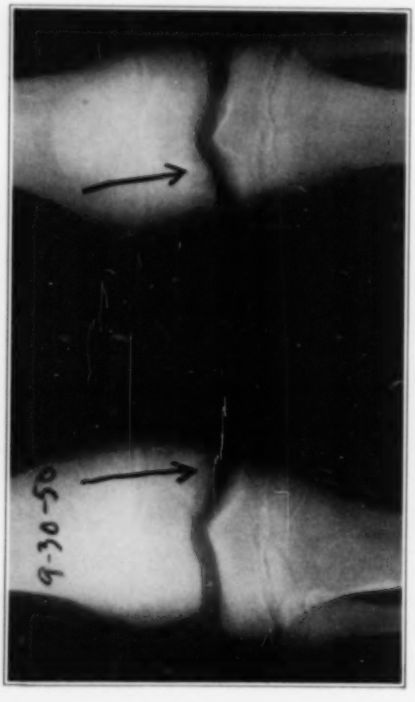


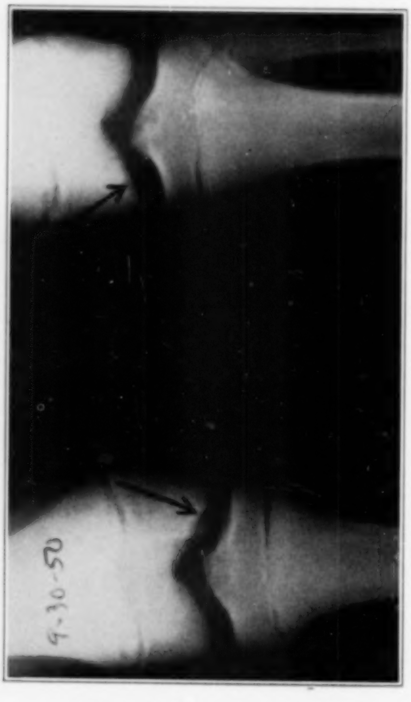
Fig. 2-D (above): Normal knees as seen by roentgenograms five months after the end of treatment.

Fig. 2-E (below): Roentgenograms made almost eight years after the end of treatment show normal joints.



9-30-50

FIG. 3-A



9-30-50

FIG. 3-B

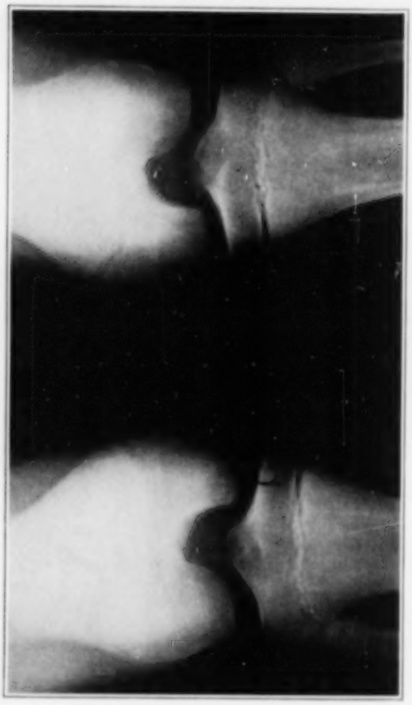
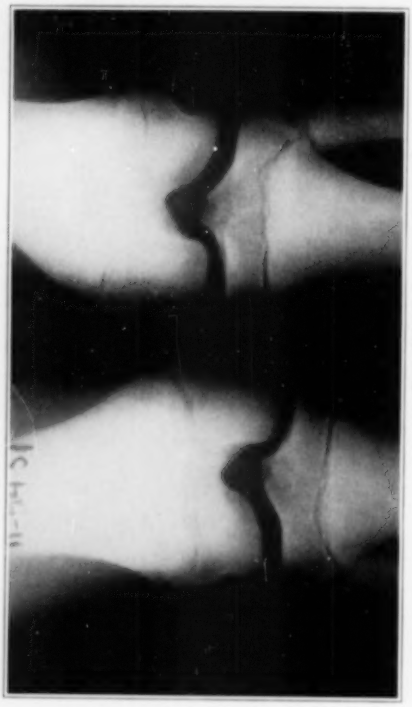


FIG. 3-C



11-14-51

FIG. 3-D

(See page 33)

Fig. 3-A: Case 3. Lesions of the medial femoral condyles are shown with moderate clarity in the ordinary anteroposterior view.

Fig. 3-B: Tunnel views show the lesions much better. Bilateral sequestrum-like areas resembling loose bodies are well demonstrated.

Fig. 3-C: Complete healing within four months.

Fig. 3-D: Roentgenograms ten months later showed normal joints.

In some of our patients, the protection of the joint was accomplished by the use of a Thomas patten-bottom brace, which prevents the joint from bearing weight (Fig. 1-E). In another group of equal size a plaster leg cylinder was applied with the knee in the amount of flexion which was needed to remove the pressure of weight-bearing from the lesion. The angle was determined for the individual case and was usually about 30 degrees of flexion. Cylinders were used in bilateral cases. The child then walked on the leg and followed the activities of which he was capable. In some of the patients who wore a patten-bottom brace, a cylinder was used for a time until the brace could be constructed. In both groups, the children were able to walk, play, go to school, and carry on independent activity. In instances in which the plaster cylinders were used, the final part of the immobilization was accomplished by bivalved plaster casts, so that active exercises might be instituted. Crutches were used for a short interval for partial weight-bearing when the plaster cylinders were removed.

TABLE IV

RESULTS IN THIRTY-SIX JOINTS

Non-operative treatment			25
Evaluated after 1 to 9 years (Average 4½ years)		18	
Excellent	17		
Unclassified	1*		
Followed less than 1 year after treatment		7	
On full activity: no defect as seen by x-ray	4		
Still protected: lesion healing	3		
Surgical treatment			9
Evaluated after 1 to 12 years (Average 7 years)			
Excellent	2		
Good	6		
Unclassified	1		
Untreated			3

* This joint was operated upon later and is included in the six good results among those treated surgically.

Those protected by the patten-bottom brace wore it for an average period of seven months (Table III). When the records of three patients who wore their brace for an excessive length of time were removed from consideration, this average was reduced to five months. As judged from the roentgenograms, the average time required for definite evidence of healing to appear was three months after treatment had been started. The lesion was barely visible in the roentgenograms after seven months on the average, and no abnormalities were seen after an average period of eleven months.

The patients who wore plaster cylinders were protected for a shorter period on the average than were those who wore braces. An average time of four months was recorded

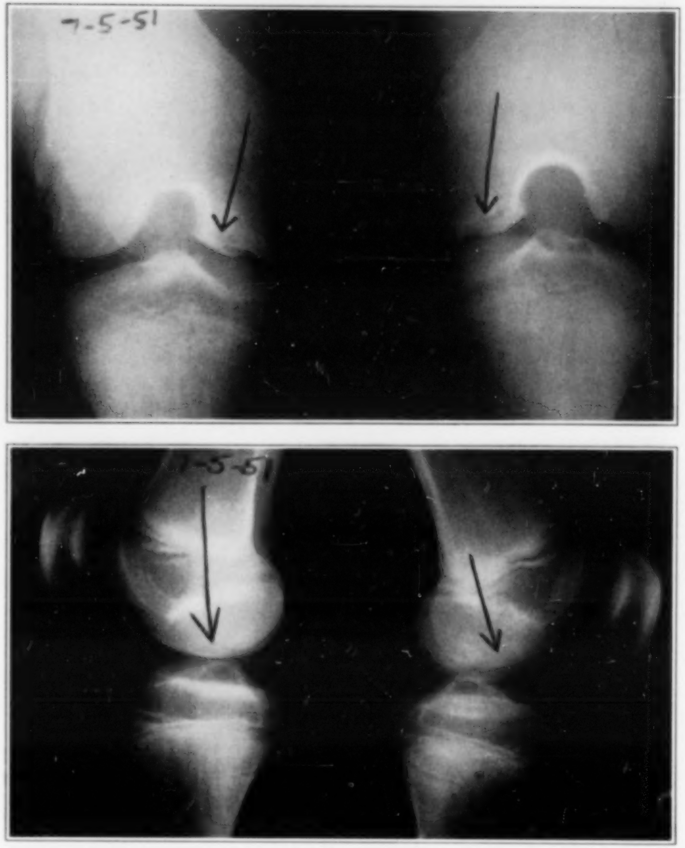


FIG. 4-A

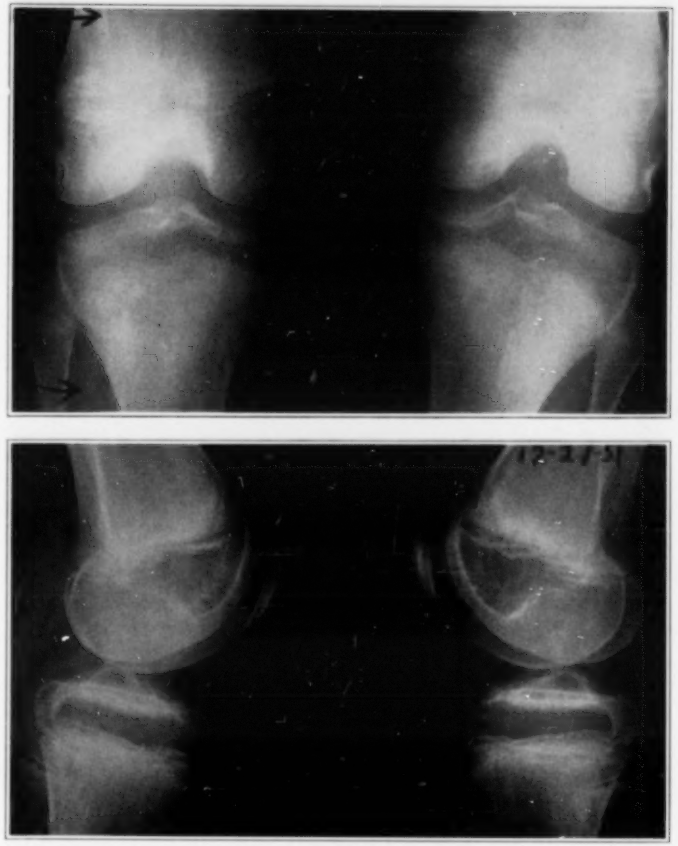


FIG. 4-B

Fig. 4-A: Case 4. Bilateral osteochondritic lesions involving the medial condyle of the femur. Sequestrum-like body may be seen on the right. Tunnel views permit good visualization. The characteristic lesions may be seen in the lateral views.

Fig. 4-B: Marked healing in five months. Defects are not discernible.

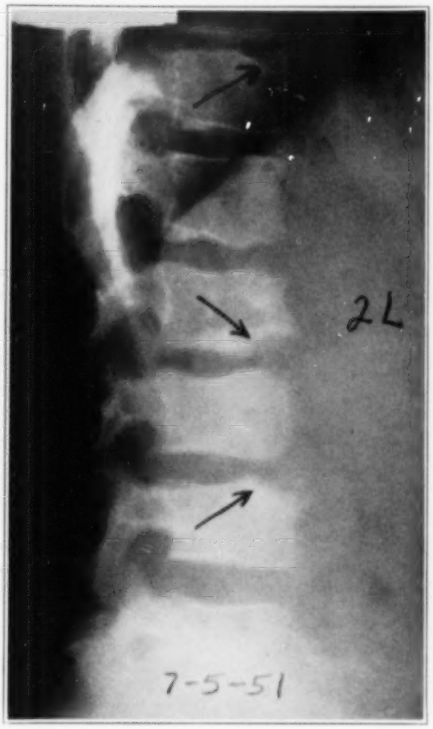


FIG. 4-C

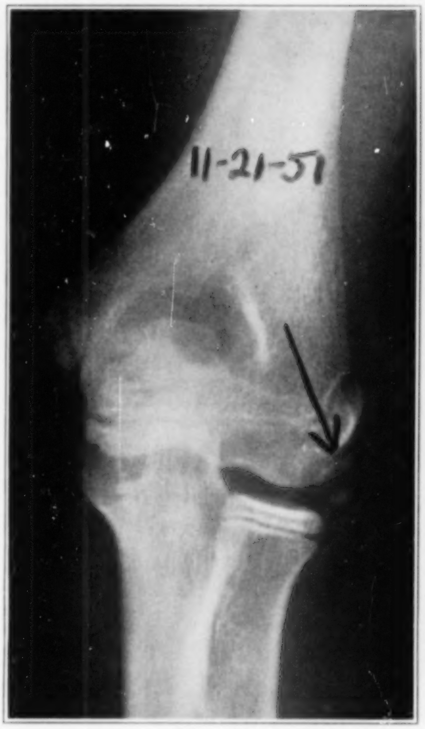


FIG. 4-D

Fig. 4-C: Case 4. Osteochondritic lesions may be seen, involving the twelfth thoracic, the second lumbar, and the fourth lumbar vertebrae.

Fig. 4-D: Typical lesion in the capitellum of the left humerus, showing sequestrum-like body.

for those who were protected by the cylinders. The healing time in the two groups was almost identical.

Of the nine patients who came to surgery, the knee was involved in seven, the elbow in one, and the ankle in one. Four had loose bodies free in the joint when first seen. Others had persistent signs and symptoms which suggested that the discharge of a free body was imminent; whereas some joints which had surgical intervention were comparable to those treated conservatively. The one knee which was treated by protection and then explored will be discussed later in some detail.

The surgical procedure was that of removal of the loose body, if one were present, and the exploration of the site of the lesion. In general the lesion was excised down to its base; in some the base was curretted. In none of the cases in this series was the site drilled. In the instance of the weight-bearing joints, some form of protection, including partial weight-bearing with crutches, was practised for an average period of two and a half months following the operation.

RESULTS

Of the twenty-five joints which were treated by protection, eighteen have had at least one year elapse since the end of treatment. All of these patients have had follow-up examinations which included thorough roentgenographic studies after an average period of four and a half years (Table IV). Seven have not been observed sufficiently long to allow such an evaluation. Of the eighteen joints, the result has been classified as excellent in seventeen; one remains unclassified. This is the knee (Case 6) which came to surgery.

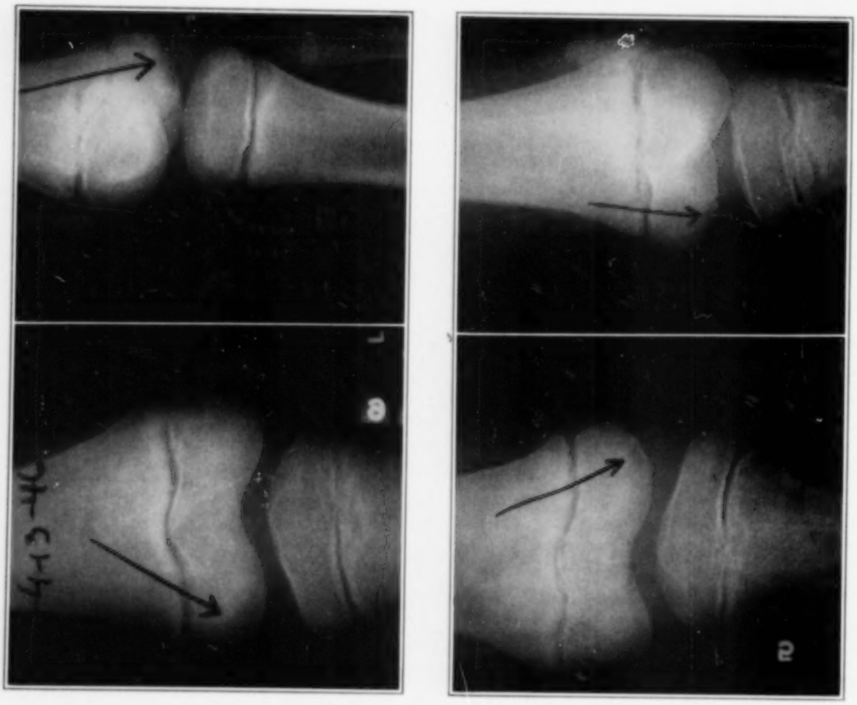


FIG. 5-A

(See page 37)

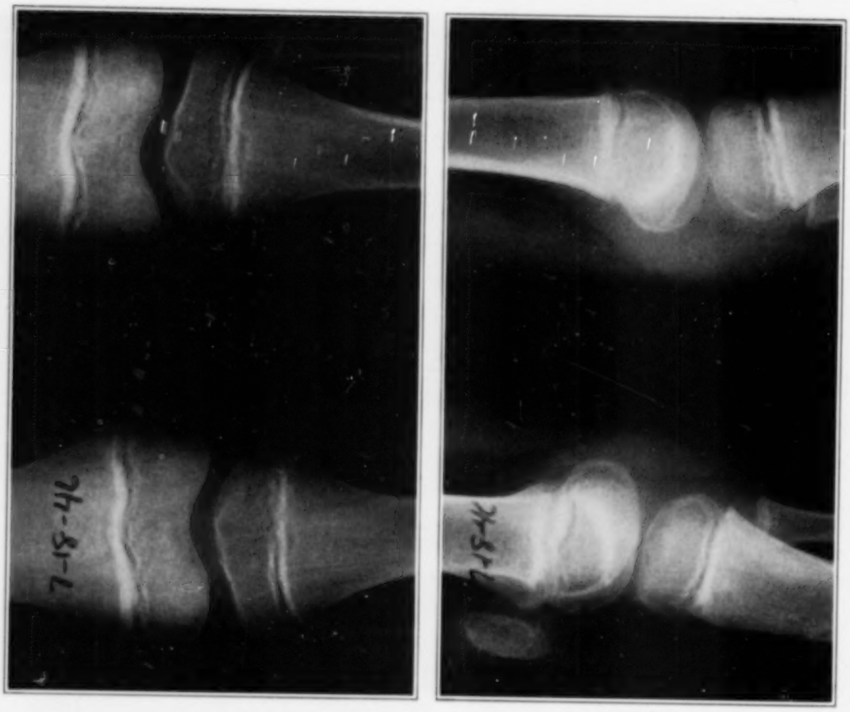

7-18-46
7-15-46

FIG. 5-B

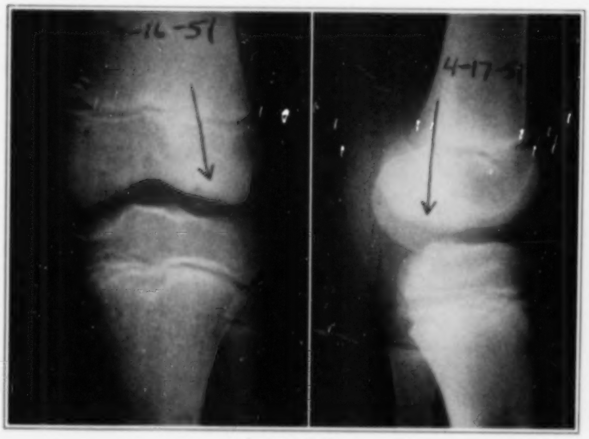


FIG. 5-C

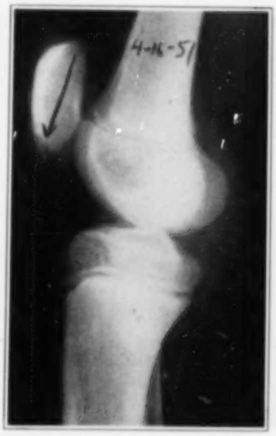


FIG. 5-E

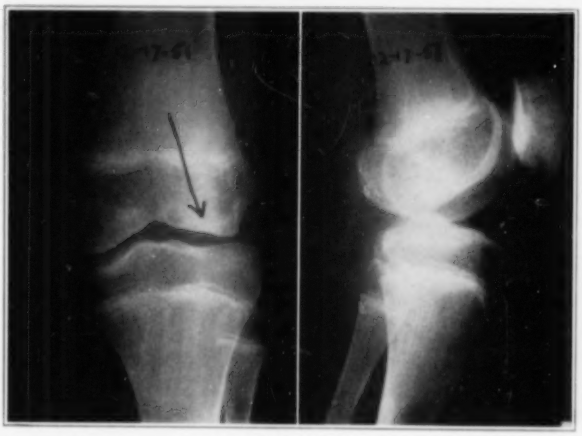


FIG. 5-D

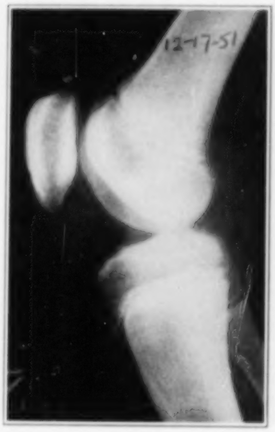


FIG. 5-F

Fig. 5-A: Case 5. Bilateral lesions in the lateral femoral condyle. Note suggestion of loose-body formation in the oblique views.

Fig. 5-B: Complete healing of all lesions within three months of the onset of treatment.

Fig. 5-C: A "new" lateral femoral condyle lesion on the left five years later.

Fig. 5-D: Almost complete healing of this new lesion after eight months of protection. The condyle seems to be a little flat, but the result cannot be evaluated at this time.

Fig. 5-E: A Larsen-Johannson osteochondritis of the right patella.

Fig. 5-F: Complete healing within eight months.

The term *excellent* has been used in these evaluations to describe a joint which appears by all criteria to be normal—that is, one which is asymptomatic and which appears to be normal by physical and roentgenographic examination.

Of the seven who have not yet been followed for one year after the end of treatment, four now have no defect evident by roentgenogram and are allowed full activity. Three are still protected, with the lesion apparently healing. In one of these the roentgenograms give the impression that some residual flattening of the condyle may be developing, but this cannot be determined at this time.

All nine patients who were treated surgically were evaluated after an average period of seven years (Table IV). The results in those operated upon should not be compared with the results in those treated by protection, since they were not comparable cases. The result in two was rated *excellent* and in six was rated *good*, with one patient unclassified.

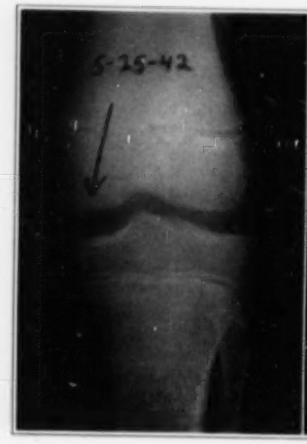


FIG. 6-A

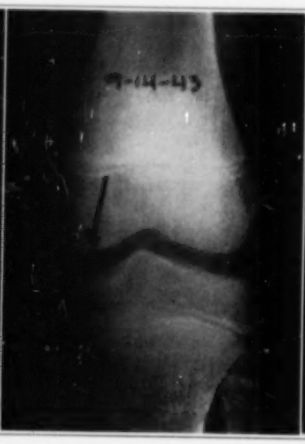


FIG. 6-B

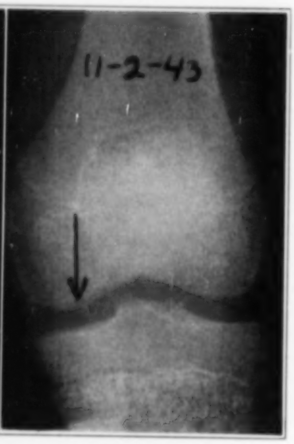


FIG. 6-C

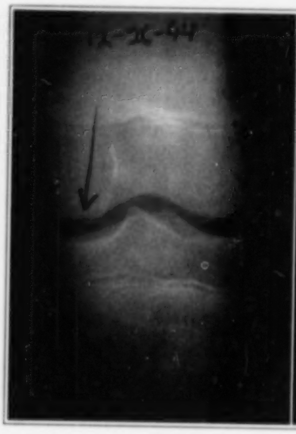


FIG. 6-D

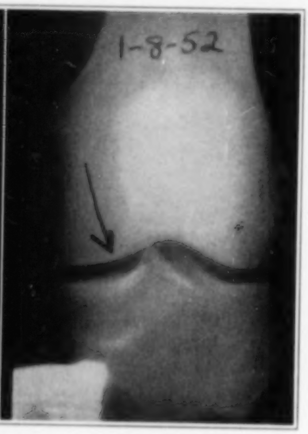


FIG. 6-E

Fig. 6-A: Case 6. Typical lesion of the left medial femoral condyle.

Fig. 6-B: Formation of loose body is questioned after sixteen months of moderate protection.

Fig. 6-C: Persistence of the appearance postoperatively.

Fig. 6-D: A persistent defect over a year postoperatively.

Fig. 6-E: Minimal squaring of the left medial femoral condyle over eight years postoperatively was noted; but the joint is essentially normal.

Good describes a joint which was found to be not quite normal on the basis of history, physical examination, and roentgenograms. In all patients in whom the joint was rated *good*, residual symptoms were minor: four had had no symptoms; two said the knee tired occasionally; and two had had aching or discomfort on rare occasions. Abnormal physical signs were restricted to three patients, two with some muscle atrophy and one in whom the elbow lacked a few degrees of full extension. In only two patients did the roentgenograms show joints which might be interpreted as normal. In the others, examinations of the roentgenograms led to such comments as the following: "a small area of irregularity in the condyle"; "a questionable squaring of the medial condyle"; and "a tiny loose body in a silent area". In three a residual defect could be seen on follow-up roentgenograms from seven to eleven years after the end of treatment.

All of these joints, when examined, had what might be called essentially normal function and the patients had no complaint; but in some there were findings which would lead one to expect future difficulty.

The patient unclassified as to result had a knee which had been the site of a septic process twelve years before and the relative factors responsible for the end result could not be weighed.

Three of the joints were untreated. Observations of two of these in one patient were quite revealing as to the natural history of the disease (Case 7).

CONSIDERATION OF INDIVIDUAL PATIENTS

The behavior of the joints involved with osteochondritis dissecans when treated by protection is illustrated by the following cases:

CASE 2. A girl, aged eleven years, was first seen on April 26, 1941, complaining of intermittent pain in both knees for one year while walking or running. Physical examination showed a normal walking gait, but the patient's running was guarded. Roentgenograms showed osteochondritis dissecans of the medial femoral condyle of each knee (Fig. 2-A).

She was protected by walking cylinders bilaterally, which were at first solid and later bivalved with 30 degrees of knee flexion, for eight months. Crutches were used for partial weight-bearing over the next three months. Thirteen months after the onset of treatment, she was allowed full weight-bearing.

At follow-up examination, nine years from the end of treatment, she was asymptomatic and physically normal. Roentgenograms showed normal knee joints (Fig. 2-E). Healing in this girl was slower than the average.

CASE 3. A girl, aged ten years, was first seen August 19, 1950, when the patient complained of "tightening" of her knees for an indefinite time, which was most noticeable when she was running. Physical examination revealed normal-appearing knee joints with a full range of motion and no measurable quadriceps atrophy. Roentgenograms showed osteochondritis dissecans to be present in the medial femoral condyle of each knee (Fig. 3-A).

She was protected by walking cylinders bilaterally and crutches for four months on the right and five months on the left. Roentgenograms showed complete healing at the end of four months (Fig. 3-C). She has been allowed full activity since then. When seen at follow-up recently, one year from the end of immobilization, she was completely well and asymptomatic. Physical examination showed normal findings. The knees, as seen in the roentgenograms were normal (Fig. 3-D).

This case illustrates the advantages of the tunnel view. Although the lesions could be seen in the anteroposterior exposures (Fig. 3-A) they were much better shown in the postero-anterior tunnel views (Fig. 3-B) where separate dense fragments were outlined. The natural inference would be that these were loose bodies which should be removed. In fact, however, the bodies still lie within the confines of the original lesion and have been rapidly absorbed.

The histories of the following two cases are presented to illustrate the multiplicity of lesions of osteochondritis which may occur and to demonstrate the association of osteochondritis of the ordinary type with osteochondritis dissecans.

CASE 4. A boy, aged thirteen, was first seen July 1, 1951. The boy complained of vague, intermittent pain in both knees for four years, usually associated with climbing stairs and with exercise. For one year before being seen he had noted intermittent, vague pain in the arms and back. His symptoms were thought to be psychiatric in origin. Roentgenograms, however, showed osteochondritis dissecans in the medial femoral condyles of both knees and in the capitellum of the left humerus, and osteochondritis involving many vertebrae (Figs. 4-A, 4-C, and 4-D). The lesions of the knee showed well outlined areas of separated bone which exhibited some apparent displacement.

Treatment consisted of protection in walking cylinders bilaterally with the knee flexed 20 degrees. He wore one on the left for two months and one on the right for three months. Roentgenograms showed evidence that rapid healing was occurring at this time (Fig. 4-B). Protection with crutches was then instituted for a short interval. Five months after the onset of treatment, his knees seemed normal as seen by roentgenogram and from physical examination. This patient is not included among these whose results have been evaluated. The elbow is being observed without treatment, and he is now wearing a long spinal brace.

CASE 5. A boy, aged seven years, was first seen April 24, 1946, when he complained of intermittent pain in the left knee posteriorly, of three years' duration. This pain often occurred late in the day or after excessive activity. Occasionally, he noted similar complaints in his right knee. For one month his discomfort was quite persistent and was associated with a left limp. The knees were not considered abnormal on physical examination; roentgenograms, however, showed osteochondritis dissecans of the lateral femoral condyle of both knees (Figs. 5-A and 5-B).

He was treated by protection in walking cylinders bilaterally for two months and was then mobilized to full activity with the protection of crutches over the following month. Roentgenograms showed rapid and complete healing of his lesions (Fig. 5-C). He was seen again April 17, 1951, almost five years after the original lesions were considered healed. He stated that, after being perfectly well in every way for three years, he began to note recurrent pain intermittently in each knee, but worse in the left knee.

Physical examination revealed relative atrophy of the right quadriceps and tenderness at the inferior end of the right patella. There was no tenderness or pain on motion of the left knee. Roentgenograms showed what appeared to be a new lesion of the left lateral femoral condyle (Fig. 5-C). On the right there was an

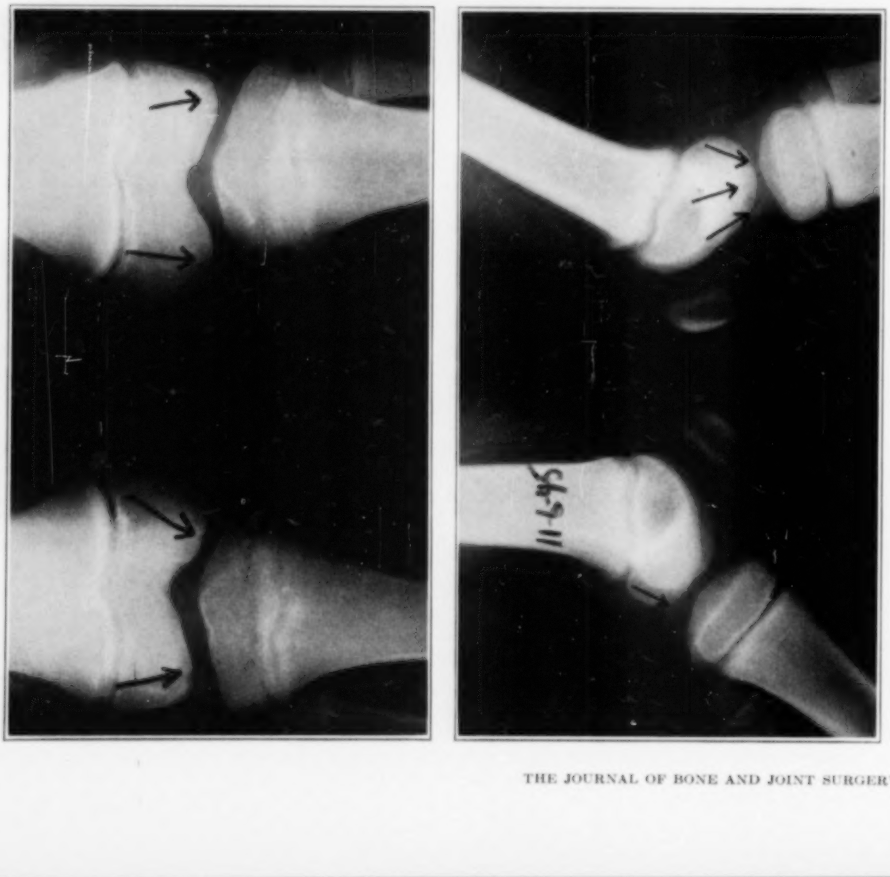


Fig. 7-A

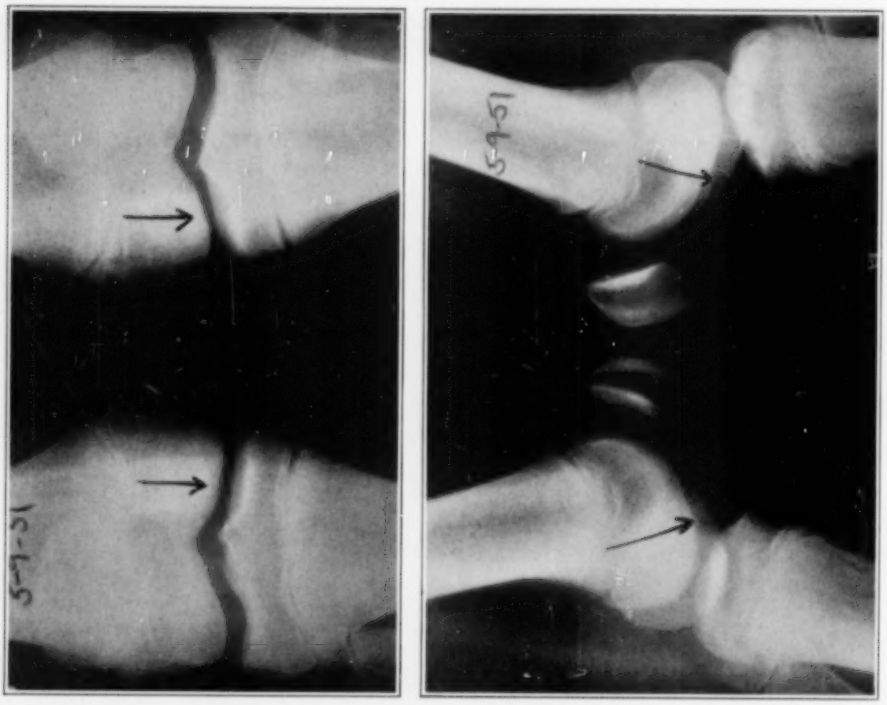


Fig. 7-B

(*See page 41*)

Fig. 7-A: Case 7. Showing bilateral osteochondritis dissecans of the medial and lateral femoral condyles.

Fig. 7-B: The medial femoral condylar lesions persist bilaterally and the lateral condylar lesions are shown to be healed five and one-half years later.

Fig. 7-C: Roentgenograms made seven years after the onset of symptoms in anteroposterior projection (above) and in postero-anterior tunnel view (below) show that the lesion is no longer visible on the left and barely detectable on the right.

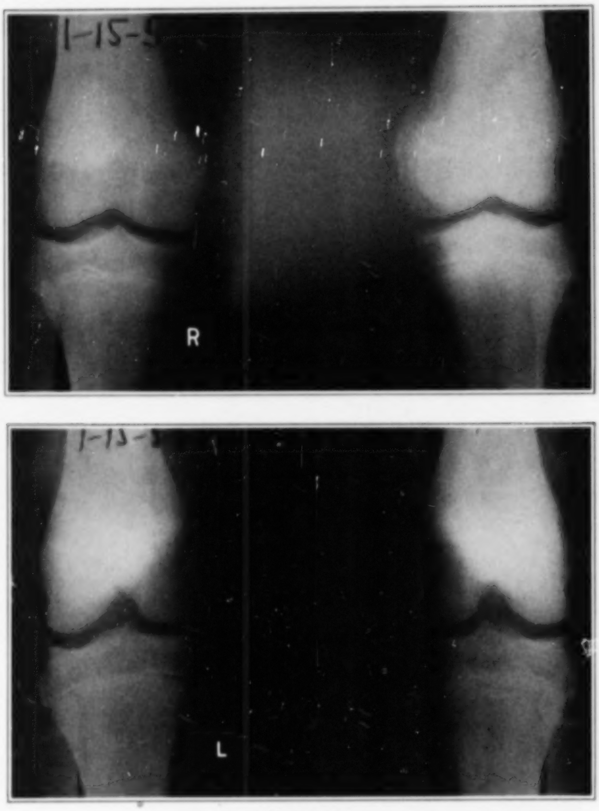


Fig. 7-C

irregularity of the patella which was interpreted as Larsen-Johannson osteochondritis (Fig. 5-E).

He was treated by protection in walking cylinders bilaterally for five months and then by a patten-bottom brace for the left leg for three months. The lesion of the right patella is healed (Fig. 5-F) and the lesion of the left lateral femoral condyle is almost healed (Fig. 5-D). He is now protected with crutches.

The latter patient (Case 5) is one of two with bilateral lesions of the knees in whom, on the evidence presented by roentgenograms, the original lesion seemed to heal and then, after an interval, new lesions seemed to develop. One cannot be sure that these lesions were not recurrences of the original process. If one refers to the roentgenograms of the patient in Case 5 (Figs. 5-A to 5-F), it will be noted that the original lesions of the femoral condyle were more posterior and lateral than was the new lesion.

Only one patient came to surgery who had been treated by protection; there is considerable doubt as to whether this was necessary.

Case 6. A boy, aged nine years, was first seen on May 6, 1942, when he gave a history of falling on his left knee at play six weeks previously. He had noted pain, swelling, and limitation of motion of this joint. Treatment consisted of a short period of bed rest and then protection with crutches. Because of a persistent limp and limited knee motion, he was admitted to this Hospital.

Physical examination revealed an effusion of the left knee with 10 degrees of permanent flexion with further flexion to 120 degrees. After one week of bed rest, the effusion of the left knee decreased and motion was almost normal. Roentgenograms showed an area of osteochondritis dissecans of the left medial femoral condyle (Fig. 6-A).

Because of his improvement, non-operative treatment was decided upon. He was fitted with a walking cylinder (in 30 degrees of knee flexion) for six weeks and then a patten-bottom splint for nine months. Following this he was allowed partial weight-bearing with crutches until July 19, 1943. In September 1943, the roentgenograms suggested to some observers the formation of a loose body (Fig. 6-B). The patient's only symptom was a left limp when he was tired.

He was, therefore, readmitted to the Hospital in October 1943 when, on physical examination, he presented a left limp and quadriceps atrophy. At operation on October 27, 1943, the articular cartilage at the site of his lesion, although soft in one small area, was intact. No loose body was seen. The area of the lesion was excised. Microscopic sections revealed only minor degenerative changes of the articular cartilage. After operation he wore a patten-bottom brace for three and a half months.

Except for an Osgood-Schlatter lesion of the right knee in 1944, he has been well since the operation. He

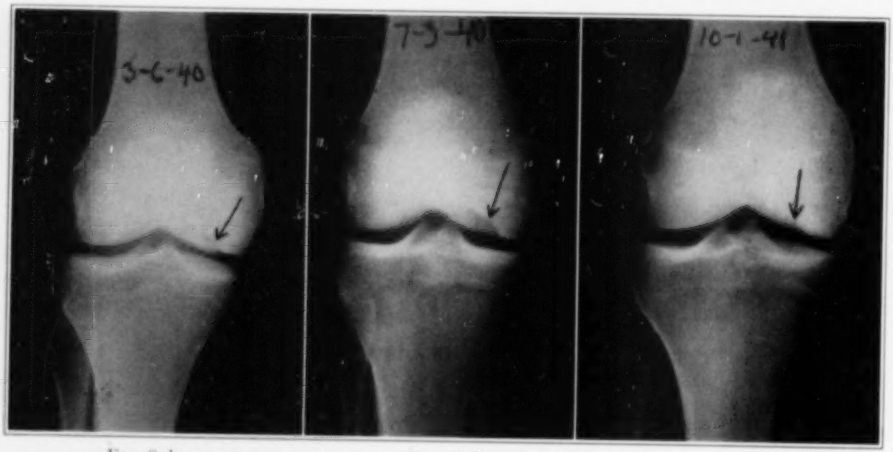


FIG. 8-A FIG. 8-B FIG. 8-C

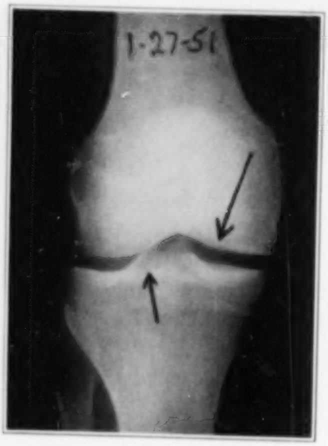


FIG. 8-D

Fig. 8-A: Case 8. Lesion of the right medial femoral condyle in which roentgenogram suggests the formation of a loose body.

Fig. 8-B: Postoperative defect.

Fig. 8-C: Persistent defect a year and a half later.

Fig. 8-D: A minimal, but persistent defect almost eleven years postoperatively. There was a loose body between the tibial spines.

was recently seen, eight years after the operation. He is asymptomatic and clinically has a normal knee joint. Roentgenograms may show minimal flattening of the left medial femoral condyle (Fig. 6-E), but it appears to be essentially normal.

It is questionable whether this joint should have been opened. In favor of operation was the fact that the roentgenograms made immediately beforehand did show a fragment (Fig. 6-B) which might be interpreted as extending beyond the cartilaginous surface into the joint cavity. Furthermore, the joint had been protected for a long interval without the lesion exhibiting roentgenographic evidence of healing. At the surgical exploration, however, the surgeon reported that there was no gross defect; no cavity could be recognized; and no subchondral weakness was determined by pressure. The cartilage in one area was softer than the normal. Although the site of the lesion was allegedly excised, bone is still seen in the area by roentgenogram (Fig. 6-C). An irregularity was visible one year after operation (Fig. 6-D); this has since filled in (Fig. 6-E).

One of our patients with both knees involved had no treatment, but he was observed periodically, so that a record of the process was established over a seven-year period.

CASE 7. A boy, aged six, was first seen on November 6, 1945, when he complained of intermittent poorly localized pain in both knees of one year's duration. There had been no antecedent trauma. No abnormal physical findings were recorded. Roentgenograms demonstrated osteochondritis dissecans in the medial and lateral femoral condyles of both knees (Fig. 7-A). Treatment was advised, but none was followed. He returned four years later with the same complaints. Findings at physical examination of both knees were reported as within normal limits except for one-half inch of quadriceps atrophy on the right. Roentgenograms showed persistence of all four lesions. Treatment was again advised, but the boy disappeared. Roentgenograms taken in May 1951 showed that lesions of the lateral femoral condyles of both knees were still present (Fig. 7-B).

This patient was examined recently seven years after the onset of symptoms. He was asymptomatic except for "aching knees when in a draft". Findings at physical examination were within normal limits except for atrophy of 1.5 centimeters of the left quadriceps. Roentgenograms showed all lesions to have healed (Fig. 7-C).

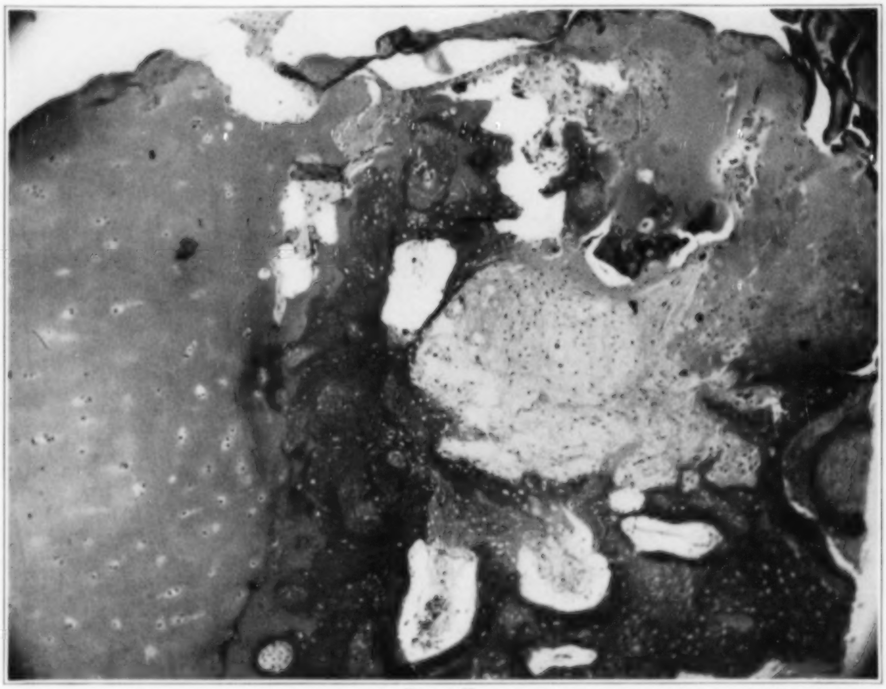


FIG. 8-E

Photomicrograph (× 125) showing viable, normal articular cartilage (at left) and extensive areas of dead subchondral bone, as well as fibrous-tissue replacement in the center of the field.

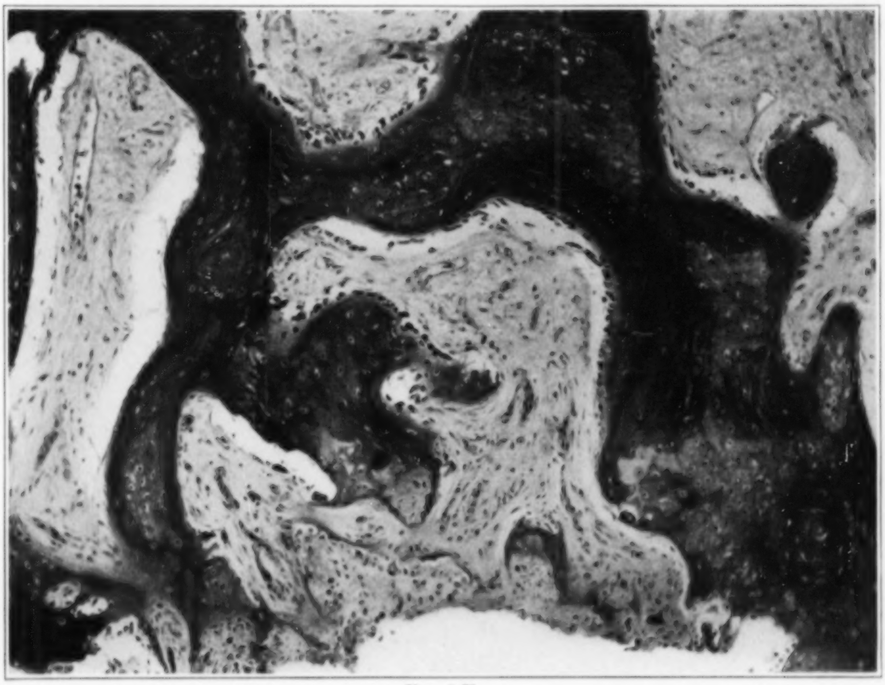


FIG. 8-F

Photomicrograph (×125) showing dead bone and active new-bone formation. In some areas, dead bone was being resorbed and replaced with fibrous tissue.

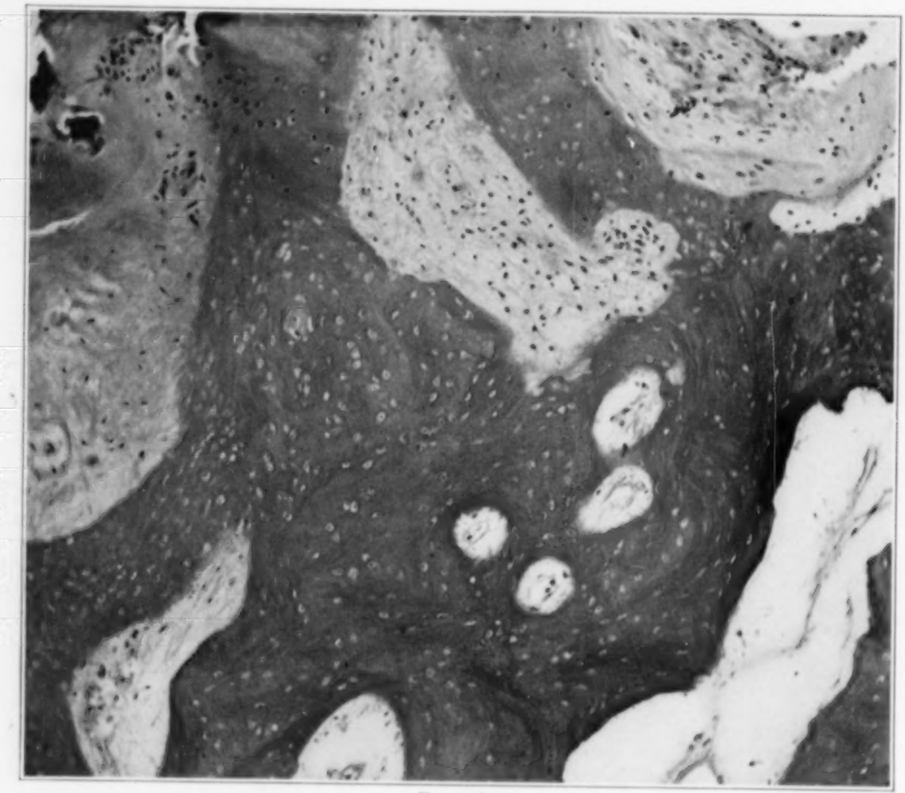


FIG. 8-G

Photomicrograph (×150) showing dead and viable subchondral bone with some fibrous-tissue replacement.

This boy had no treatment; he was a non-athletic type who was only moderately active. It took about seven years for the lesions of the medial condyle to heal which is quite in contrast with the time required for healing of those treated by protection.

The gross and microscopic character of the process and the course after operative excision are illustrated in the following case:

CASE 8. A girl, aged fifteen years, was first seen on March 6, 1940, complaining of intermittent pain, of four to six months' duration, at the lower pole of the right patella.

The physical examination revealed essentially normal findings except for slight atrophy of the quadriceps on the right. Roentgenograms showed a lesion of osteochondritis dissecans of the medial femoral condyle of the right knee with what appeared to be a large sequestrated bone fragment *in situ* (Fig 8-A).

At operation on April 29, 1940, the cartilage at the site of the lesion showed a grayer color than the normal and was cracked along one margin of the subchondral defect. This area was excised and the base was curetted. Postoperatively, she was protected for a few months with crutches and partial weight-bearing

Microscopic sections showed well preserved articular cartilage except in the area adjacent to the fracture. A great part of the subchondral bone was not viable. In many areas there was fibrous-tissue replacement; in others, osteoid tissue and new bone (Fig. 8-E, 8-F, and 8-G).

The patient was seen eleven years after operation and was noted to be asymptomatic although some years before she had had two periods when she had had some discomfort in the joint for a few days Physical examination gave normal findings. Roentgenograms (Fig. 8-D) showed a minimal but persistent defect still present, as well as a small loose body which was attached in the intercondylar notch and did not disturb the articular surface.

DISCUSSION

Here and there in the literature are reports of spontaneous healing of osteochondritis dissecans [2, 5, 11, 19, 20, 21, 22, 25, 28, 29, 30, 33, 34]. Decker, for example, found healing as shown

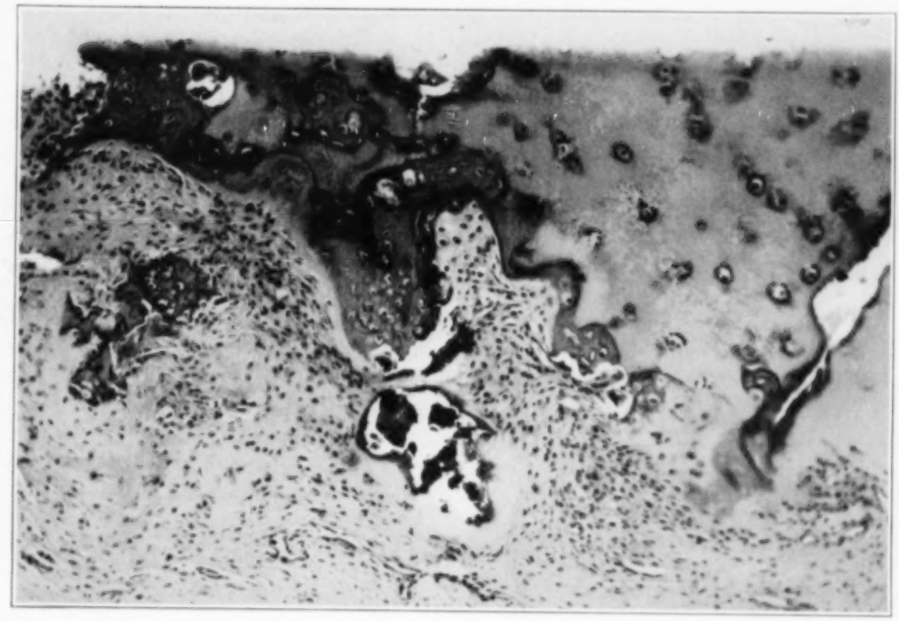


FIG. 9

Section of specimen (×250) removed from the elbow of fourteen-year-old boy with three and one-half months of painful, limited motion of the left elbow. Roentgenogram revealed a typical lesion of the capitellum of the left humerus. At operation, the articular surface of this area was soft and discolored, but it was intact. The whole lesion was excised. The boy was asymptomatic at follow-up one year later, but he had minimal limitation of elbow motion.

The articular cartilage was viable, but certain areas showed some degenerative changes. The subchondral bone had been resorbed except for a few scattered islands; it had been replaced by fibrous tissue, osteoid, and new bone.

by roentgenogram and clinical improvement after treating a patient by bed rest for six months. Strange, in 1944, reported a case of a boy, four and a half years old, with a knee lesion that healed six weeks after being immobilized in a cast. Wiberg felt that the lesions were more likely to heal spontaneously in younger persons than in older patients [33, 34].

Our experience would suggest, first, that osteochondritis dissecans is not uncommon in children and, second, that, when the lesion is protected, the process can heal quite promptly. This can occur even in the patients in whom there is apparent sequestral formation within the confines of the cavity of the osteochondritic lesion.

Three of the lesions in our series which were treated by protection were first exposed by operation but were left undisturbed. One of these was exposed for the purpose of treating the osteochondritic lesion (Case 1); the other two lesions were observed at the time that discoid menisci were removed. In each of these three joints, the cartilage over the osteochondritic lesion was of normal color, and the site of the defect could be recognized only by placing heavy pressure upon the cartilage to demonstrate the resilience arising from the subchondral defect. In all three, there was an extensive defect and a sequestrum within the area, as visualized in the roentgenograms. When the extremities were protected, the lesions healed quite promptly (Figs. 1-A to 1-D).

The histological evidence in the patients who came to operation in this series, and in our older patients, would confirm the idea that the basic process in osteochondritis dissecans is an aseptic necrosis involving the subchondral bone and that all other changes are secondary (Figs. 8-E to 8-G and 9).

One can make certain deductions about the course of the lesion as it has been seen in the child. For some reason the subchondral bone, and the bone immediately subjacent, dies. The cartilage in the beginning remains healthy, since it obtains its nutritional requirements from the synovial fluid. As dead bone is absorbed, the cartilage loses its mechanical support, is subjected to trauma, and, as a result, shows varying degrees of softening and degenerative change. The cartilage may crack along the margin of the defect and may be extruded into the joint along with the subjacent involved bone. On the other hand, if the joint is protected so that the cartilage does not become broken, the dead bone can be invaded, absorbed, and the lesion can heal by "creeping substitution".

This, from our clinical experience, is quite a dependable occurrence in osteochondritis dissecans of children when the affected joint is protected. Thus, protection seems to be the treatment of choice in children, provided there is no loose body in the joint and provided the clinical manifestations subside quite promptly.

Healing can go on spontaneously in joints which are not protected, but in the two instances which we have observed this required almost seven years, as contrasted with the prompt healing which ordinarily occurs when the joint is protected.

The fact that relatively few cases of osteochondritis dissecans in children have been described may depend upon several factors. In most of the cases the symptoms have been relatively mild and intermittent, and the physical findings have been normal, or relatively normal, in many. The lesion may not be seen in the roentgenograms unless they are of good quality; and, occasionally, special views are necessary to visualize the defect. Furthermore, the lesion may heal spontaneously or may continue to exist and only be extruded at an older age.

The etiology of osteochondritis dissecans remains in doubt. Trauma is usually given first consideration as a causative factor either through direct injury or indirectly by interruption of the vascular supply of the subchondral bone [4, 32]. In considering etiology, however, attention should be given to the high frequency with which multiple lesions occur. Usually these are symmetrical, but occasionally one sees a patient with multiple lesions in various joints without evidence of symmetry in their distribution. Even more impressive is the high incidence in our patients of osteochondritis of the ordinary type, particularly of lesions of the tibia and of the spine. Over 20 per cent. of the patients with osteochondritis dissecans showed osteochondritis of other types. These findings suggest that there is some underlying factor which makes the individual particularly susceptible to osteochondritis dissecans and to osteochondritis in general.

Osteochondritis dissecans has a significant incidence in childhood. Usually at this age, treatment may be expected to lead to spontaneous healing without residual deformity. In the majority of instances surgical intervention is not indicated.

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DISCUSSION

Dr. Charles H. Herndon, Cleveland Heights, Ohio: This has been a most interesting presentation, and we are indebted to Dr. Green and Dr. Banks for bringing to our attention the facts that osteochondritis dissecans is not uncommon in children and that, if it is treated early and adequately by conservative measures, we may expect most lesions to heal without resulting deformity. I have been under the impression, as I believe most orthopaedic surgeons have, that osteochondritis dissecans is a disease which occurs in adults and which is distinctly uncommon in children.

After I was asked to discuss this paper, I investigated and found that at the Gates Memorial Hospital for Crippled Children there had been only two cases of osteochondritis dissecans in the knee out of over 6,000 admissions to the Diagnostic Clinic. Still, Dr. Green and Dr. Banks have seen thirty-two cases during the past twelve years—apparently seven of these were seen during the past year. Either we must be missing the diagnosis in many instances or else the children have had such mild symptoms that they were not referred to our Clinic. It is entirely possible that many of the lesions with definite craters and separating fragments which we see in young adults began during childhood. If these cases had been diagnosed early and had been treated conservatively before the osteochondritic fragment had separated, we probably could have avoided the development of a permanent irregularity of the joint surface which almost invariably ensues after the removal of a separated fragment. It is apparent that, if complete healing with no irregularities in the articular surface can be accomplished with conservative measures, it is the treatment of choice.

Dr. Green and Dr. Banks have adequately demonstrated that, if immobilization and protection are initiated before there is a break in the articular cartilage, healing with no irregularities will occur. Of course, if the patient is not seen until after the fragment has separated, we have no alternative but to remove the

(*Continued on page 64*)

ROTATION OSTEOTOMY IN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP *

BY EIVIND PLATOU, M.D., OSLO, NORWAY

From the State Orthopaedic Hospital, Oslo

The importance of increased anteversion of the femoral head and neck in congenital dislocation of the hip became abundantly clear to the author some years ago. At that time, at the State Orthopaedic Hospital in Oslo, we began to employ open reduction routinely in every case of congenital dislocation of the hip in which ideal position was not achieved by closed reduction or in which the dislocation recurred in the first plaster cast. These operations clearly demonstrated the fact that, when the existing anatomical obstacles to bloodless reduction were removed, it was necessary to rotate the limb internally to 40 degrees, to 80 degrees, or even to 90 degrees in order to ensure a correct position of the

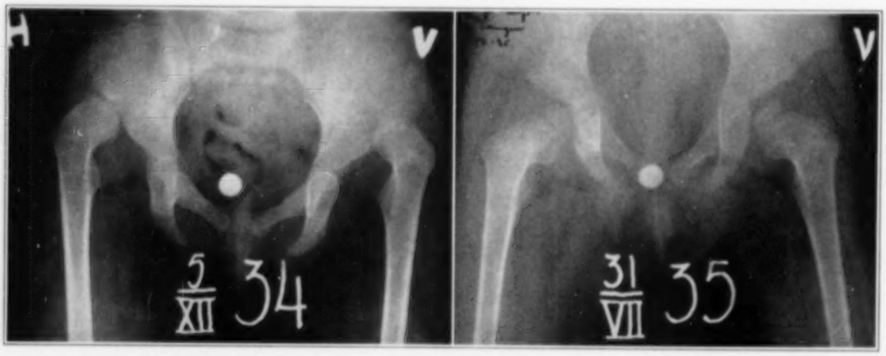

Fig. 1-A

Fig. 1-B

These x-rays show the consequences of defective rotation osteotomy.
Fig. 1-A: December 5, 1934. Å. T., three years old. Roentgenogram made before reduction.
Fig. 1-B: July 31, 1935. Roentgenogram made at the end of treatment.

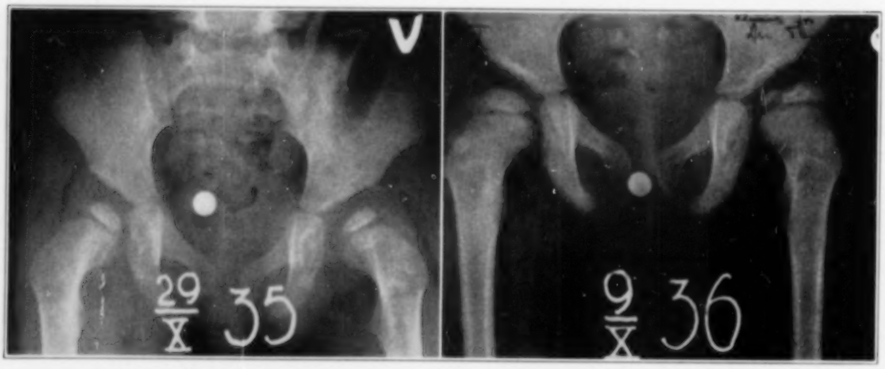

Fig. 1-C

Fig. 1-D

Fig. 1-C: October 29, 1935. Roentgenogram showed the axis of the femoral head and neck pointing too high on the left side. Under present methods of treatment, a rotation osteotomy would have been performed.
Fig. 1-D: October 9, 1936. The roentgenogram revealed subluxation.

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* Presented at the Fifth Congress of the International Society of Orthopaedic and Traumatic Surgery, Stockholm, Sweden, May 1951.

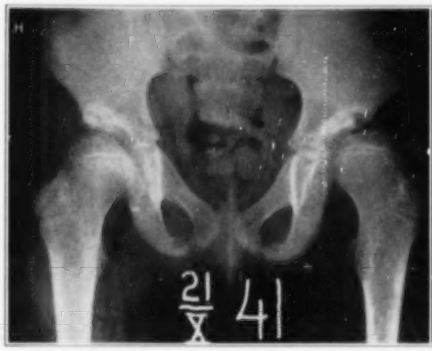

Fig. 1-E

October 21, 1941

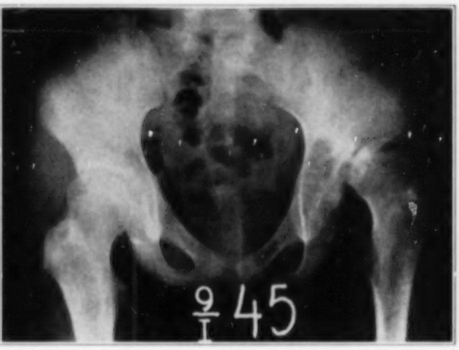

Fig. 1-F

January 9, 1945

Both roentgenograms revealed uniform increase of upward displacement.

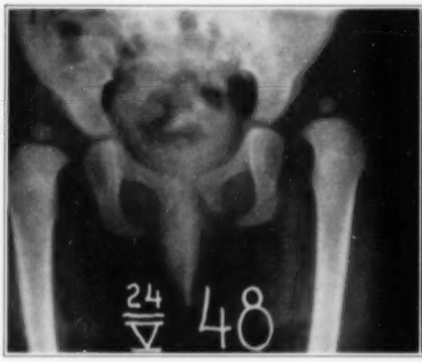

Fig. 2-A

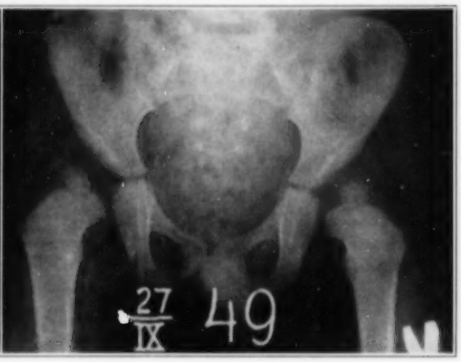

Fig. 2-B

Fig. 2-A: May 24, 1948. A. K., two years old. Roentgenogram made before reduction.

Fig. 2-B: September 27, 1949. Roentgenogram made nine months after discharge with the limb in such a position that the patella was pointing straight forward.

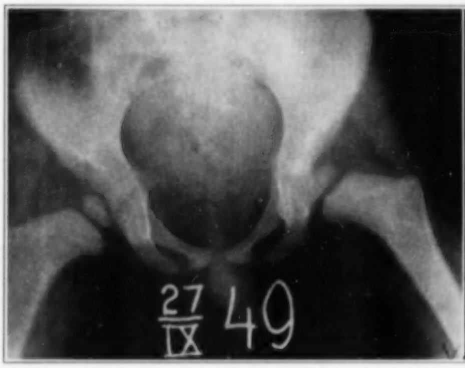

Fig. 2-C

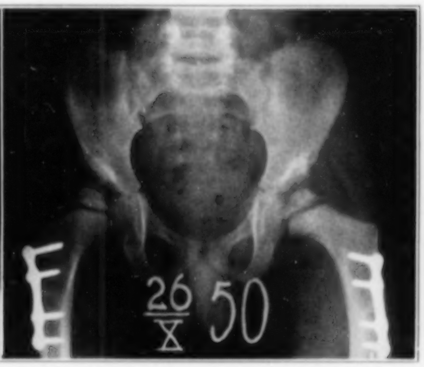

Fig. 2-D

Fig. 2-C: September 27, 1949. Roentgenogram made with both limbs internally rotated 80 degrees.

Fig. 2-D: October 26, 1950. Roentgenogram made eleven months after rotation osteotomy with the limb in such a position that the patella was pointing straight forward and the axis of the head and the neck of the femur was pointing directly at the Y cartilage.

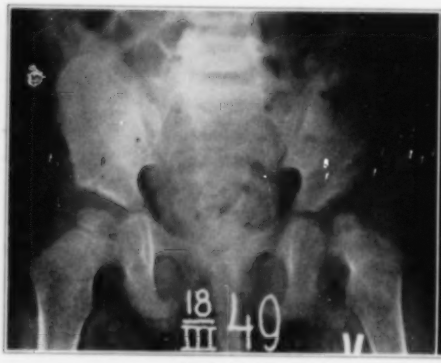

FIG. 3-A

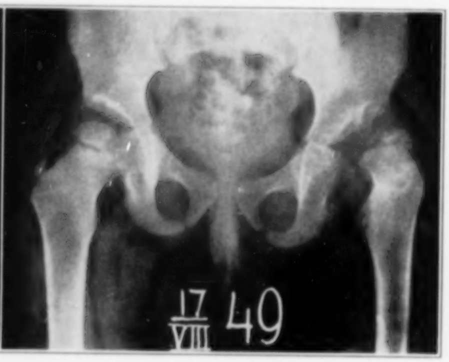

FIG. 3-B

Fig. 3-A: March 18, 1949. Å. O. Position of the head of the femur at the end of treatment.

Fig. 3-B: August 17, 1949. Roentgenogram revealed incipient redislocation. The limb was in such a position that the patella pointed straight forward.

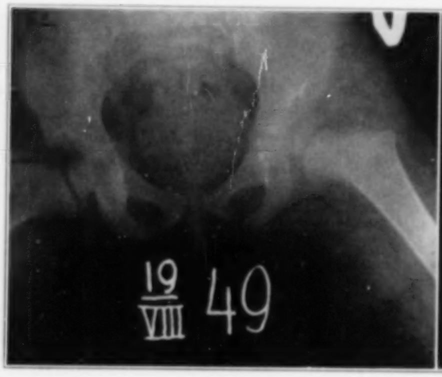

FIG. 3-C

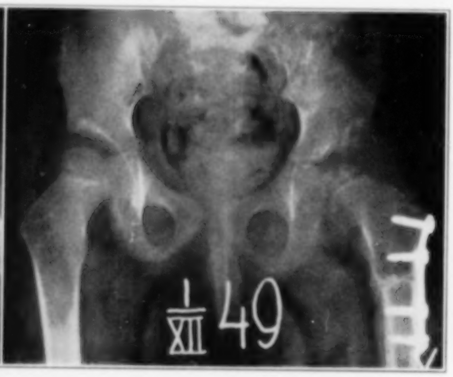

FIG. 3-D

Fig. 3-C: August 19, 1949. Roentgenogram made with the left limb internally rotated 80 degrees.

Fig. 3-D: December 1, 1949. Roentgenogram made three months after rotation osteotomy was done. With the patella pointed straight forward, the head and neck of the femur pointed toward the acetabulum.

Fig. 3-E: December 13, 1950. Roentgenogram made one year and three months after rotation osteotomy was done.

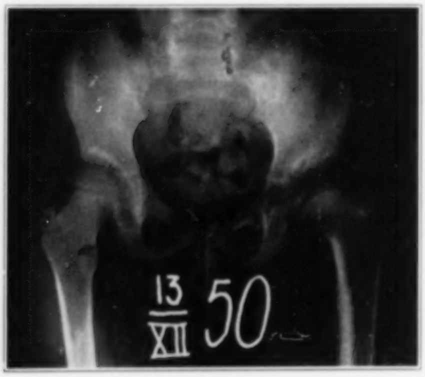

FIG. 3-E

femoral head in the acetabulum. However, in this position the child could not walk; and, when the plaster cast was removed, the foot was carried outward automatically with an anterior dislocation resulting in the more severe degrees of anteversion or a slowly increasing subluxation resulting from atrophy of the upper border of the acetabulum due to the pressure of the femoral head there rather than in the center of the acetabulum. We therefore set out to adjust the leg so that the patella pointed directly forward when the head of the femur was in the correct position in relation to the acetabulum. This could only be attained by osteotomy.

It is common knowledge that in a considerable proportion of congenitally dislocated

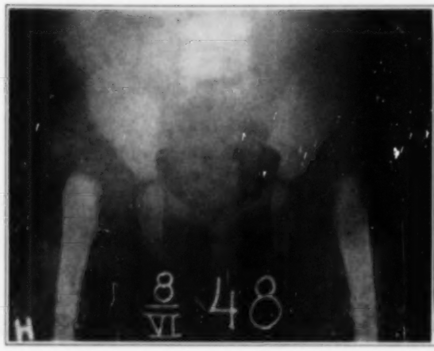

FIG. 4-A

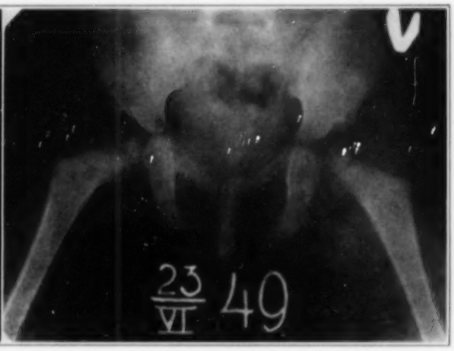

FIG. 4-B

Fig. 4-A: June 8, 1948. E. F. Roentgenogram made at admission to Hospital.

Fig. 4-B: June 23, 1949. Roentgenogram made after reduction, with the hips in 45 degrees of internal rotation.

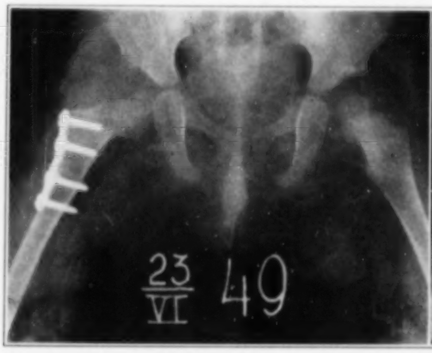

FIG. 4-C

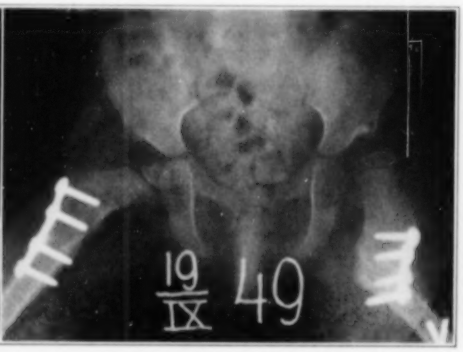

FIG. 4-D

Fig. 4-C: June 23, 1949. Roentgenogram made after rotation osteotomy of the right hip (rotated to 40 degrees).

Fig. 4-D: September 19, 1949. Roentgenogram made seven weeks after rotation osteotomy of the left hip to 45 degrees. The screws had lost their hold on the lower fragment.

Fig. 4-E: September 26, 1949. Roentgenogram made after re-operation on the left hip. Insufficient rotation was obtained.

hips the anatomical conditions are much worse two or three years after reduction than would have been expected on the basis of the roentgenographic appearance at the completion of treatment.

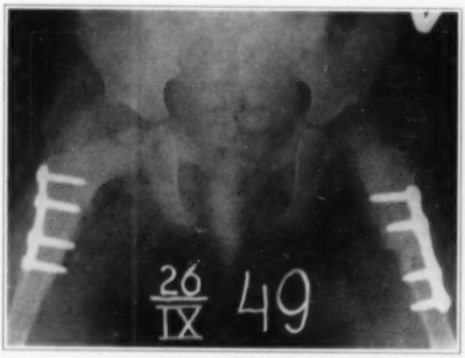

FIG. 4-E

During the period from 1934 to 1947 at the State Orthopaedic Hospital in Oslo, 297 children with congenital dislocation of the hip were treated with closed reduction. The follow-up investigation of 276 of these children (404 hips) three to fifteen years after reduction showed that fifty-one patients (sixty hips—15 per cent.) had abnormal anteversion, that is, more than 30 degrees.

The roentgenograms of these sixty hips showed satisfactory conditions in only eight. Among the remaining fifty-two, there were thirty with subluxation and twenty-two with

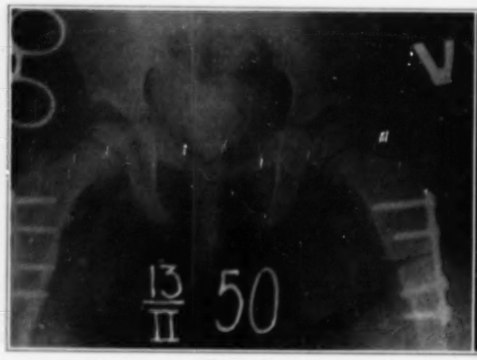

FIG. 4-F

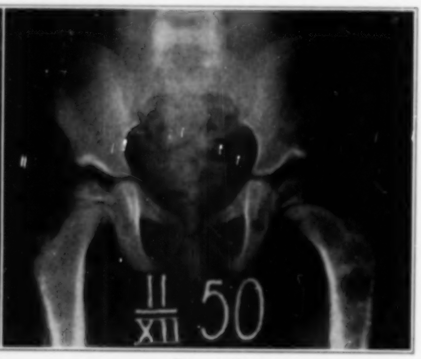

FIG. 4-G

Fig. 4-F: February 13, 1950. Roentgenogram made after a new rotation osteotomy. The left hip was in 50 degrees of rotation.

Fig. 4-G: December 11, 1950. Roentgenogram made ten months later: clinical condition, excellent.

redislocation. Therefore, from the evidence presented in the roentgenograms, the results were bad in 87 per cent.

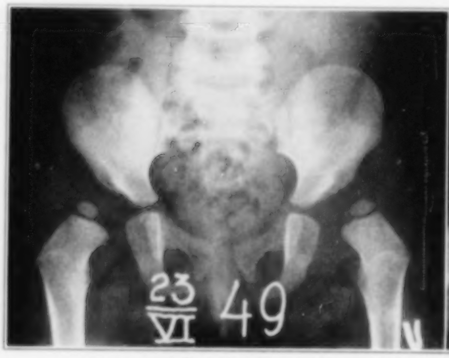

FIG. 5-A

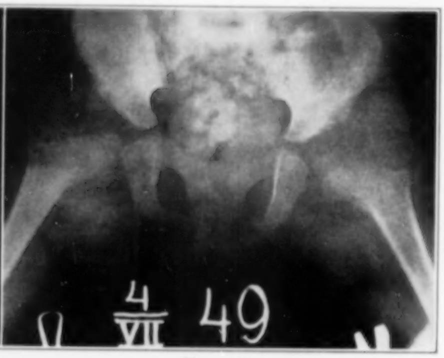

FIG. 5-B

Fig. 5-A: June 23, 1949. M. L., two years of age. Roentgenogram made before reduction.

Fig. 5-B: July 4, 1949. Closed reduction could not be obtained on either side; open reduction was, therefore, done. Both hips had to be held in 80 degrees of internal rotation.

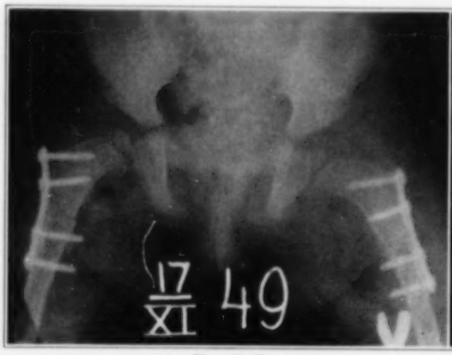

FIG. 5-C

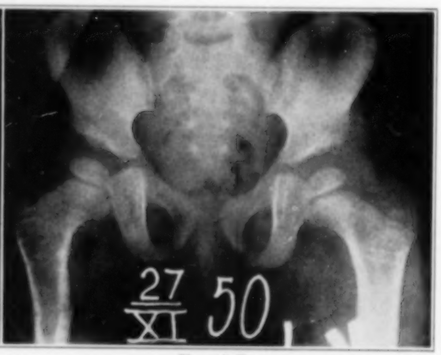

FIG. 5-D

Fig. 5-C: November 17, 1949. Roentgenogram made after rotation osteotomy had been performed bilaterally.

Fig. 5-D: November 27, 1950. Roentgenogram made one year later. The patella was pointing straight forward when this film was made.

In contrast with this, however, taking the whole series of 404 hips, only 34 per cent. showed bad results—a remarkable difference.

In the light of our present experience, we are convinced that rotation osteotomy gives much better results, as seen by roentgenogram, than those obtained in hips not so treated. The serial roentgenograms included in this article emphasize the value of rotation osteotomy.

TECHNIQUE

When immobilization in plaster-of-Paris is terminated five months after closed reduction or two to three months after open reduction, anteroposterior roentgenograms are made with the patella pointing directly forward. If the longitudinal axis of the head and the neck of the femur does not point directly at the Y cartilage, new roentgenograms are made with the limb in various degrees of internal rotation from 30 to 90 degrees. The amount of internal rotation gives the correct relationship and indicates the degree of anteversion.

When it is necessary to rotate the limb internally more than 35 degrees, a rotation osteotomy is performed.

The upper end of the femur is exposed from a point just below the lesser trochanter up to the greater trochanter. A Lane four-hole Vitallium plate is secured by two screws to the lateral side of the femur as closely to the tip of the greater trochanter as possible, after a roentgenogram has shown that the longitudinal axis of the head and neck of the femur is pointing directly at the Y cartilage. The femoral shaft is then sawed through with a Gigli saw just below the lesser trochanter at the mid-part of the plate. The lower fragment is rotated outward until the patella points directly forward, the angle varying between 30 and 90 degrees. The lower fragment is then secured to the plate by two more screws. Fixation in plaster is continued for eight weeks; after exercises in bed for three or four weeks, the child is allowed to be up and about. The plate is removed in six months or a year after the procedure.

RESULTS

As of May 1950, we have performed thirty-seven rotation osteotomies on thirty patients, twenty-three of whom had one hip affected and seven of whom had both hips affected. The average age upon admission to the Hospital was two years. The rotation angle varied from 30 to 90 degrees, 58 degrees being the average.

Upon discharge from the Hospital, the position of the head of the femur was good in thirty-two cases and not satisfactory in five. Of the unsatisfactory, three had not had sufficient rotation for complete correction and in one patient coxa vara developed, necessitating subtrochanteric osteotomy, after which the position of the head in the acetabulum was not quite satisfactory. In the remaining patient who had had bilateral rotation osteotomy, position was lost in both hips when the screws pulled out. A second operation was unsuccessful on one side. In two patients position was also lost when the screws pulled out. Re-operation resulted in an ideal position in one and a fair position in the other.

The observation period is still too short to permit final evaluation of results; but considering that an ideal position of the hip was achieved at the time of discharge from the Hospital in thirty-one out of thirty-seven hips operated upon and that, after a follow-up period of from nine months to five years, twenty-nine of these cases still showed a position which was either good or ideal, it may be concluded with some certainty from our experience that rotation osteotomy is a further help in the treatment of congenital dislocation of the hip.

Our previous experience had shown that nearly all of the hips which were reduced by open reduction sooner or later either subluxated or redislocated. It was formerly our custom to perform a shelf operation in these cases, but this was not successful as long as the head of the femur pressed against the upper rim of the acetabulum. The series of 404 hips reviewed here demonstrated this fact quite clearly. There were sixty hips which showed a pathological degree of anteversion; in nineteen of these hips a shelf operation was done, upon which now a rotation osteotomy would be undertaken. The results of these nineteen operations were as follows:

Clinical result: good in eight, not good in eleven;

Roentgenographic result: good in two, not good in seventeen.

SUMMARY

In treating congenital dislocation of the hip in the presence of increased anteversion of the femoral head, the author has done rotation osteotomy just below the lesser trochanter (from 30 degrees to 90 degrees) on thirty-seven hips in thirty patients. At the time of the patient's discharge from the Hospital, good position was noted in thirty-two hips. At follow-up examination from nine months to five years later, good position had been retained in twenty-nine hips.

Presidential Address

(*Continued from page 4*)

intimately with your Executive Committee in behalf of the Association and to have received their wise suggestions and counsel in planning the year's activities has been a most rewarding experience, one that will be cherished for many years to come.

As President, one becomes better acquainted with the loyal contributions made by your officers and committee members. Their continued sincere efforts, added to those of their predecessors since 1887, have made The American Orthopaedic Association what it is today. Dr. Mitchell, Dr. Mauck, members of the Executive Committee, Dr. Blount, Dr. Cole, committee chairmen and members have carried the major load and have been responsible for the Association's perpetuation. None of these illustrious men outshine our faithful, hard-working Editor and his Editorial Board. We all take great pride in the high position attained by our *Journal*. Our most heartfelt thanks to them.

As I leave the office in which I have felt it such an honor to serve, my most sincere wish for all of you is that you may be receptive of the tribute paid to doctors by Jeshua, the son of Sirach, early in the second century before Christ. He writes in Ecclesiasticus, 38[1]:

"Show the physician due honor in view of your need of him,
For the Lord has created him;
Healing comes from the Most High,
And he will receive presents from the King.
The skill of the physician exalts him,
And he is admired among the great."

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[1] From An American Translation, by Edgar J. Goodspeed. Chicago, University of Chicago, 1938.

INCIDENCE OF TUMOR METASTASIS TO THE LUMBAR SPINE

A Comparative Study of Roentgenographic Changes and Gross Lesions*

BY J. M. YOUNG, M.D., AND F. JAMES FUNK, JR., M.D., MEMPHIS, TENNESSEE

From the Departments of Pathology and Orthopaedic Surgery, Kennedy Hospital, Memphis

This study was undertaken to determine the frequency of tumor metastases in bone. In the performance of routine necropsies, it became apparent that gross deposits of tumor in bone were more frequently seen than one would expect from figures hitherto reported. Coley states that the frequency of skeletal metastases is not generally appreciated because of the lack of routine skeletal examination at necropsy, and cites Kitain as saying that skeletal metastases develop in 10 per cent. of all carcinomata. Schmorl in 1932 summarized his findings on diseases of the spine; he encountered secondary deposits of tumor in 4.64 per cent. of the spines of persons of all ages. He cited Rohrhirsch's series in which 500 tumor deaths in men showed spine metastases in 19.6 per cent., while in 500 tumor deaths in women the incidence was 15.6 per cent. Geschickter and Copeland believe that about 50 per cent. of cases of mammary, renal, prostatic, and lung carcinoma show skeletal metastases in the terminal phases. As early as 1917 Symmers reported a 12 per cent. incidence [Symmers' report actually states 17 per cent., but this percentage is an error] of bone metastases in 298 cases in which autopsy was done, and Hubeny and Mass reported an incidence of 12 per cent. in 1,365 cases. Turner and Jaffe reviewed 1,303 autopsies in cases of tumor and reported bone metastases in 18.4 per cent. Abrams in a comprehensive study of a wide variety of tumors found an incidence of 27.2 per cent. for bone deposits in 1,000 consecutive cases of malignant epithelial tumors. One of the highest figures for skeletal metastases (40 per cent.) is reported by Stein, who studied wedges of bone from many different sites in seventy-eight cases.

It is common knowledge that destructive changes produced by metastases in the spine are late to appear in the roentgenogram, unless the tumor incites an osteoblastic reaction. Schmorl was among the first to emphasize the lack of correlation between roentgenographic changes and gross extent of tumor metastasis in bone. He described the work of Chasin and Böhmig and Prévort who created small defects (1 to 1.5 centimeters in diameter) in trabecular bone and failed to find these by x-raying the specimens. Snure and Maner state that a lesion without cortical destruction usually does not appear in the roentgenogram. Borak created artificial defects in vertebral bodies and found that extensive destruction of the trabecular bone failed to produce a lesion detectable by roentgenogram. In 1948 Schackman and Harrison were impressed by the discrepancy between roentgenograms made near the time of death and anatomical bone lesions, and they referred to the statement by Willis in 1934 that the tumor process "almost always" first fills the marrow spaces and only secondarily produces a reaction in the bone. They reported four illustrative examples with roentgenograms of specimens removed from the body for comparison. Wolfson and his associates felt justified in beginning deep roentgen therapy to the spine in tumor cases on evidence from clinical and laboratory examinations, even when roentgenographic evidence was negative.

METHOD

This report is based on an analysis of seventy-four consecutive cases of fatal tumor, occurring between March 1950 and May 1951, in which autopsies were done. The lumbar portion of the spine was chosen for study because of its representative location and avail-

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* Based on an exhibit presented at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 1951.

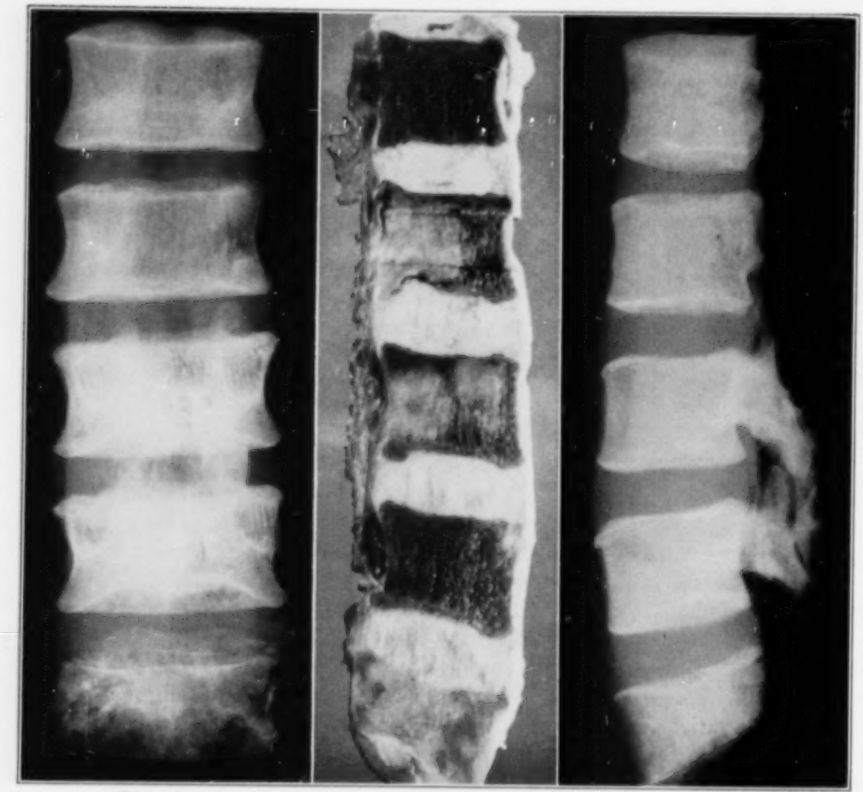

Fig. 1-A Fig. 1-B Fig. 1-C

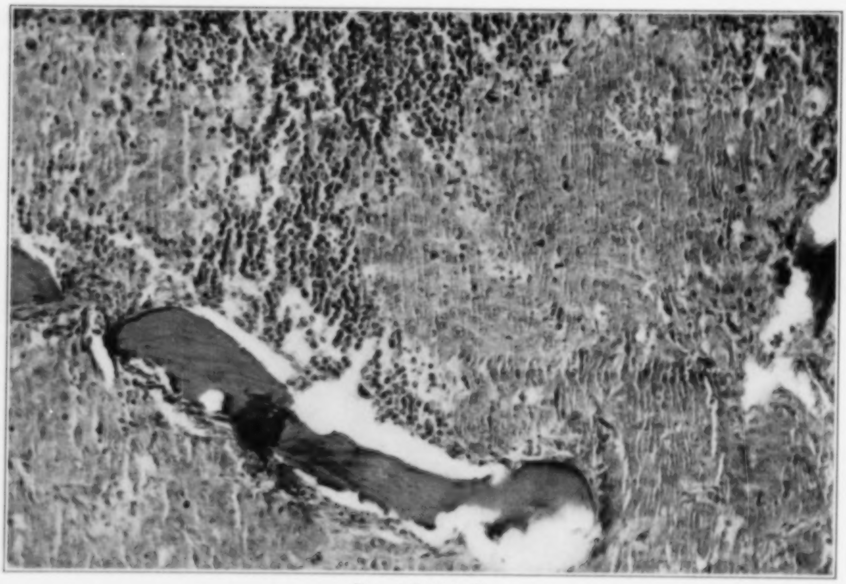

Fig. 1-D (× 45)

Bronchogenic carcinoma. The focus in the third lumbar vertebra is not seen in the x-rays. The focus in the second lumbar vertebra has destroyed the cortical bone posteriorly.

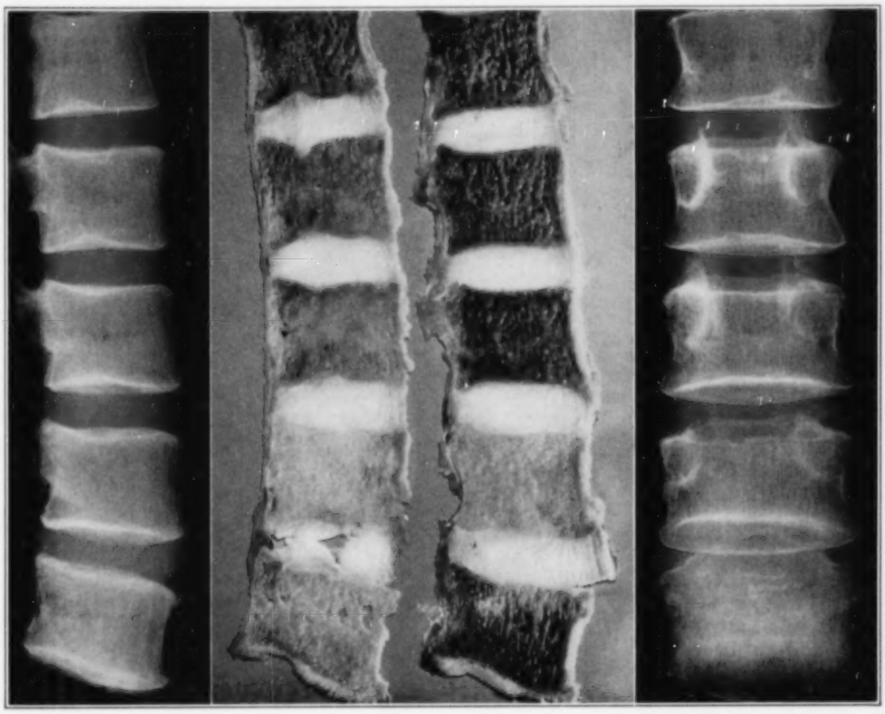

FIG. 2-A FIG. 2-B FIG. 2-C

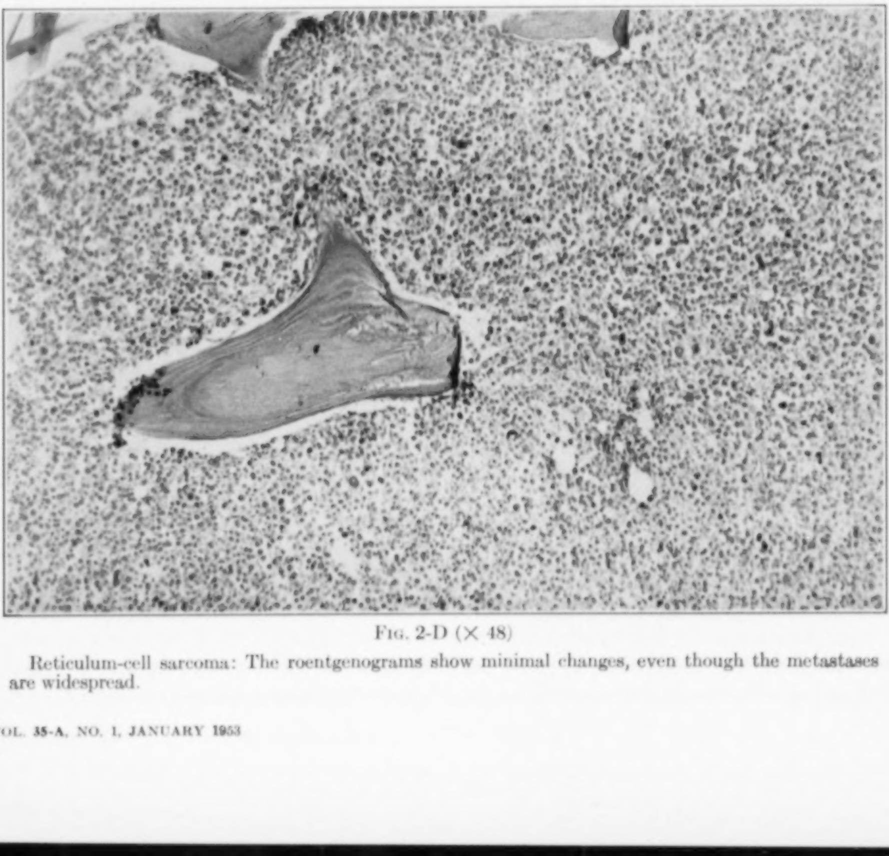

FIG. 2-D (× 48)

Reticulum-cell sarcoma: The roentgenograms show minimal changes, even though the metastases are widespread.

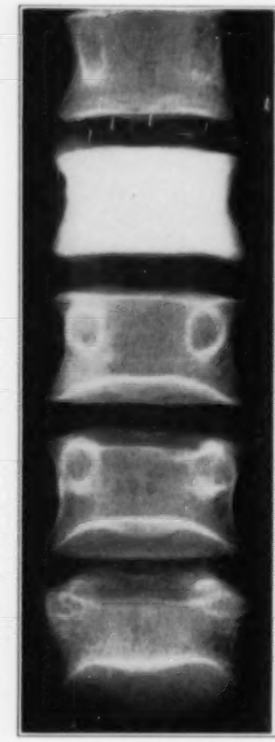

FIG. 3-A

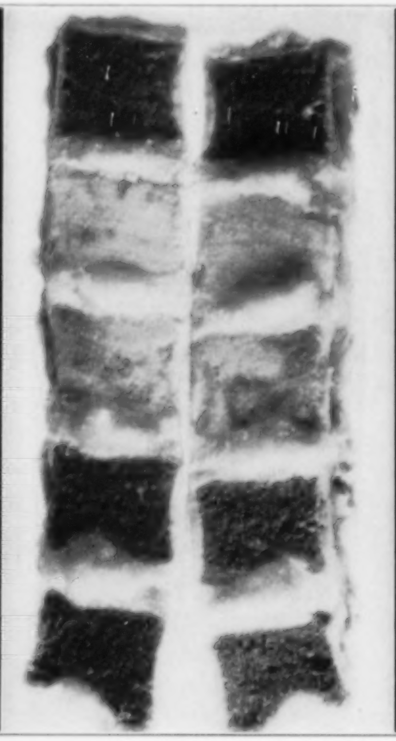

FIG. 3-B

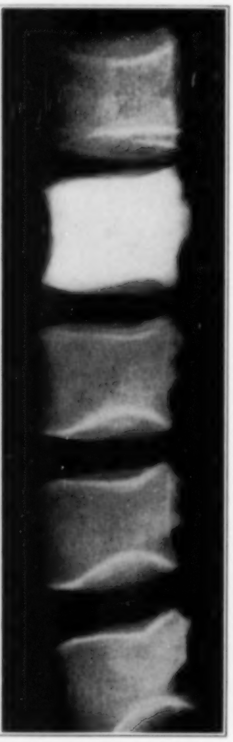

FIG. 3-C

ability. It is a large segment of bone with abundant red marrow, where tumor metastases are usually situated. At the time of autopsy, the lumbar portion of the spine was removed by transecting the pedicles and the intervertebral discs at the level of the twelfth thoracic, the first lumbar and the fifth lumbar vertebrae, and the first sacral segment. Next the specimen was x-rayed in the anteroposterior and lateral positions and then sliced into multiple sections lengthwise in the anteroposterior direction. Multiple sections were taken from each specimen for microscopic study and were decalcified in an electrolytic decalcifier. Tissue sections were stained with hematoxylin and eosin by our standard autopsy technique.

RESULTS AND DISCUSSION

In Table I are listed the tumors studied, the cases in which metastases were found, and the positive roentgenographic evidence. Included in this series are three types of tumor which may arise in bone as a primary site. The original lesion in the case of osteogenic sarcoma began in the tibia and later metastasized to many tissues, including the lumbar portion of the spine. The case of reticulum-cell sarcoma began as a lymphoblastic type of lymphosarcoma in the axillary and inguinal lymph nodes, and later involved the spine. The case of multiple myeloma was included because it was a case of tumor death; almost always this disease begins in bone and frequently in the spine. Two of these three cases showed positive roentgenographic evidence of pathological changes. Thus there are thirty cases with gross metastases, an incidence of almost 41 per cent. In only thirteen did the roentgenograms disclose significant lesions, even though there were no overlying soft-tissue shadows. The metastases in three cases appeared in the roentgenograms as osteoblastic areas and in two others as mixed osteoblastic and osteolytic foci. Osteolytic foci

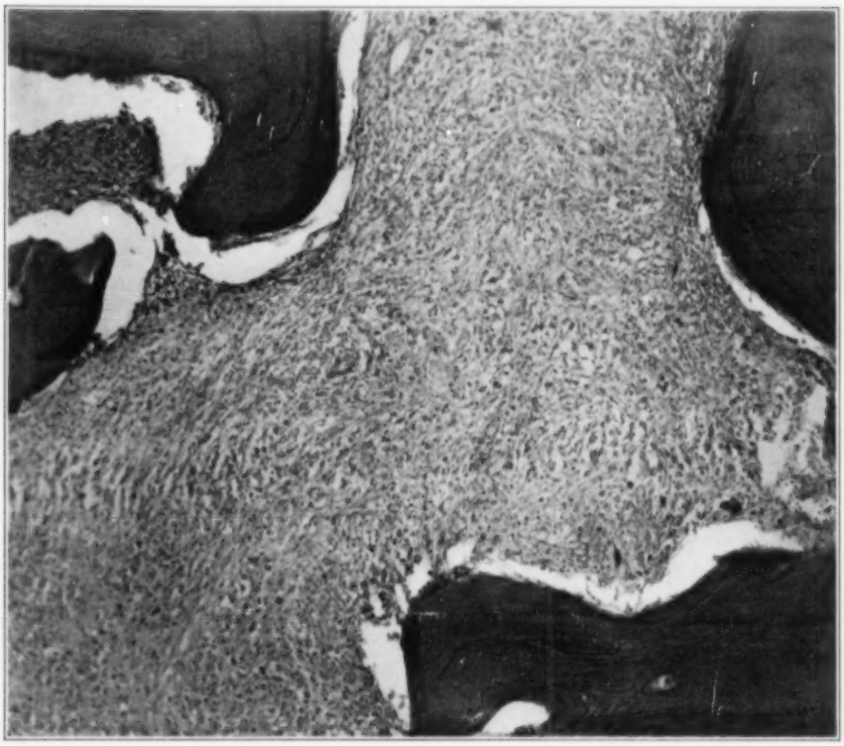

FIG. 3-D (× 36.5)

Figs. 3-A to 3-D: Hodgkin's disease: This dense osteoblastic reaction is unusual in Hodgkin's disease. Note relative absence of roentgenographic evidence of osteoblastic reaction in the third lumbar vertebra. Note also the dense trabeculae in the microscopic section.

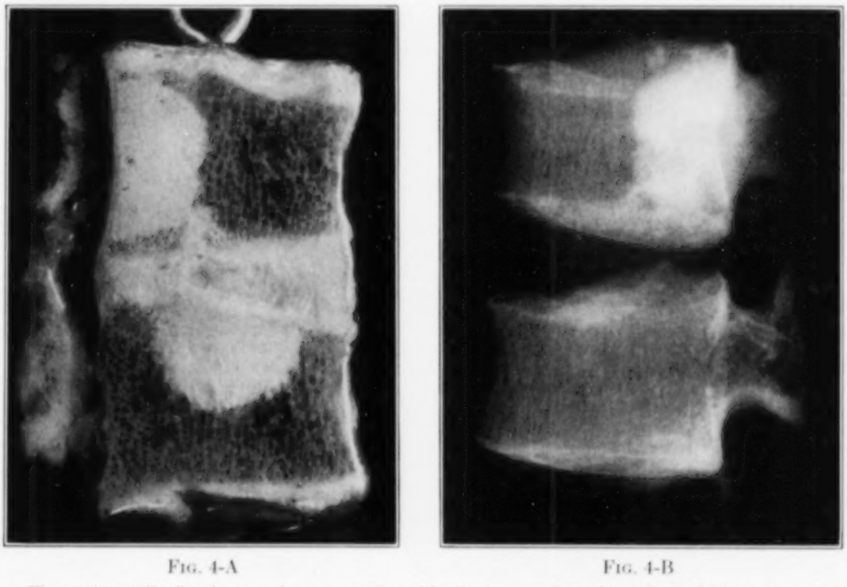

FIG. 4-A FIG. 4-B

Figs. 4-A to 4-D: Carcinoma of pancreas: Osteoblastic areas such as those shown here are revealed early by x-ray.

Note abundant osteoid tissue in microscopic section (Figs. 4-C and 4-D taken from upper focus).

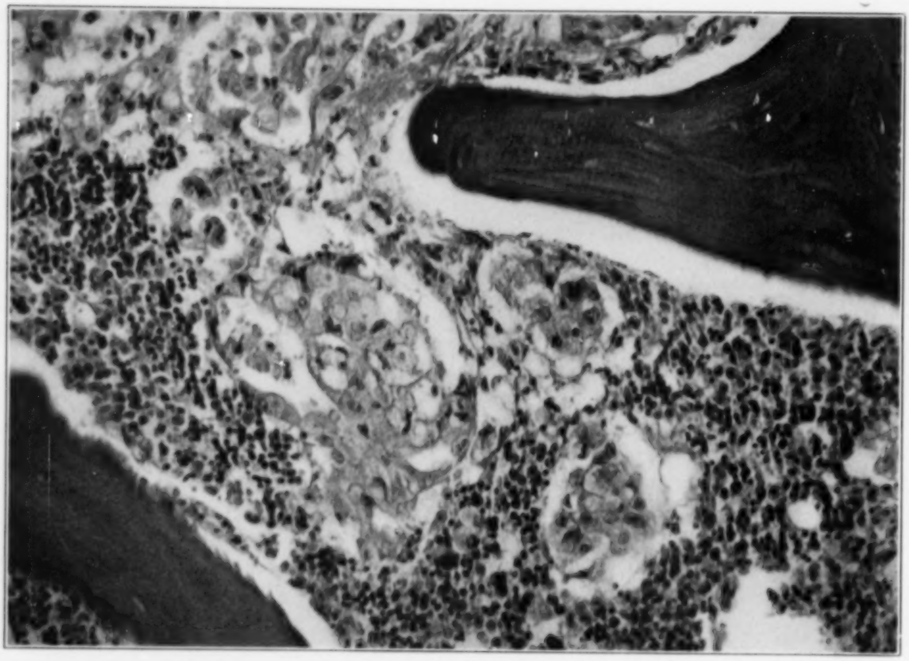

FIG. 4-D (× 85)

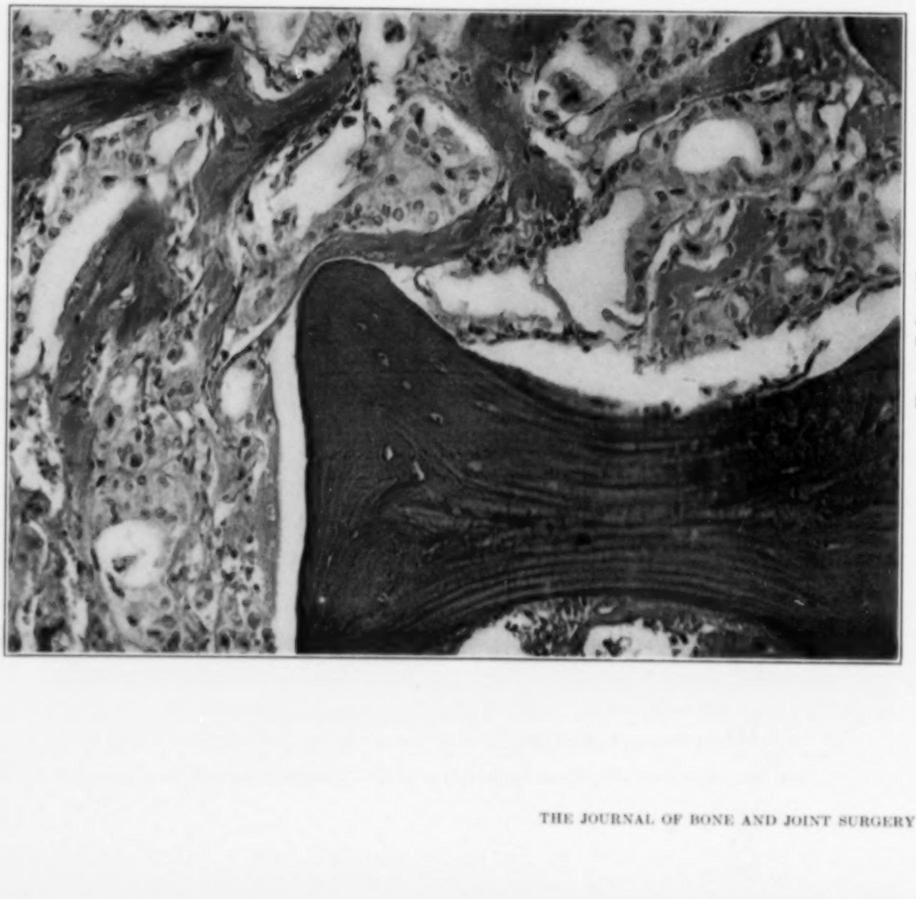

FIG. 4-C (× 85)

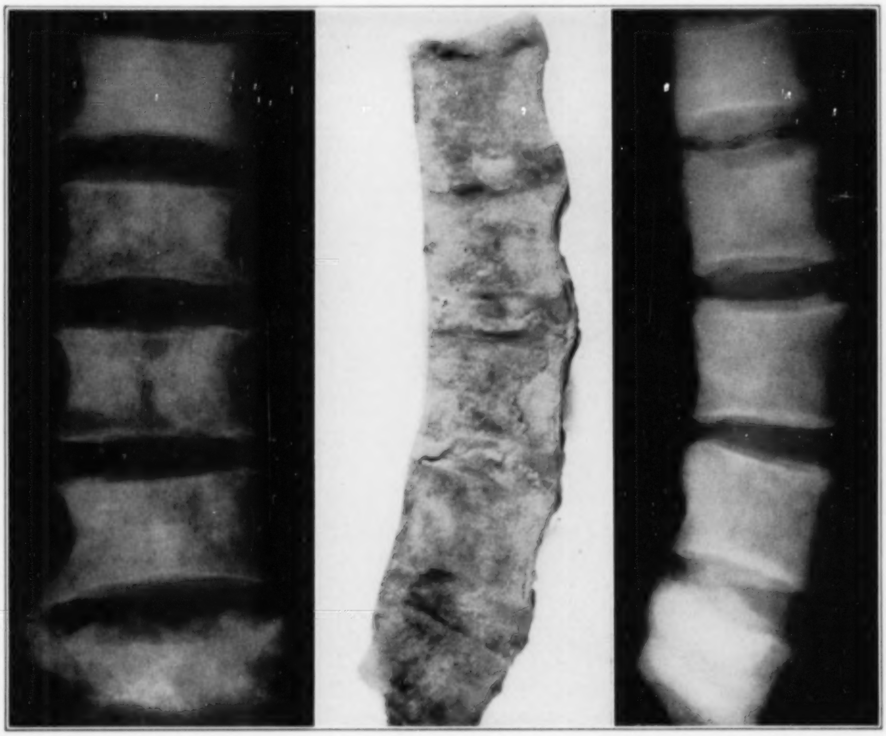

Fig. 5-A Fig. 5-B Fig. 5-C

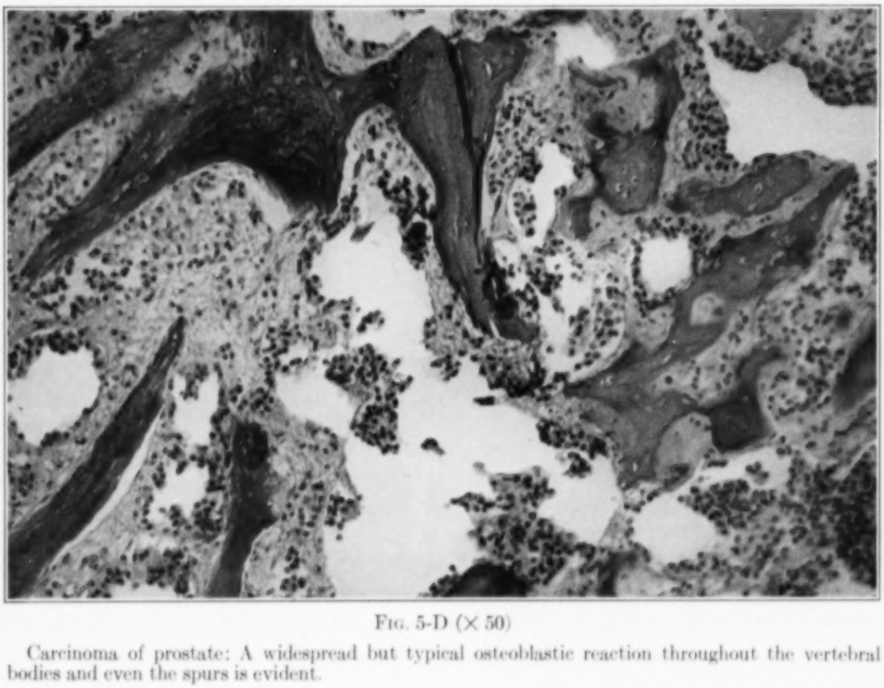

Fig. 5-D (× 50)

Carcinoma of prostate: A widespread but typical osteoblastic reaction throughout the vertebral bodies and even the spurs is evident.

TABLE I

ANALYSIS OF CASES STUDIED

Type of Tumor	Number of Cases Studied	With Gross Metastases (in Lumbar Spine)	With X-Ray Findings
Bronchogenic carcinoma	20	8	3
Hodgkin's disease	8	5	1
Carcinoma of pancreas	6	2	1
Carcinoma of stomach	5	1	1
Carcinoma of liver	5	1	
Carcinoma of oesophagus	5		
Malignant melanoma	4	3	1
Carcinoma of kidney	3	2	1
Carcinoma of larynx	3	1	
Carcinoma of prostate	2	1	1
Carcinoma of bladder	2	1	1
Reticulum-cell sarcoma	2	1	
Osteogenic sarcoma	1	1	1
Carcinoma of sweat gland	1	1	1
Multiple myeloma	1	1	1
Carcinoma of frontal sinus	1		
Carcinoma of tonsil	1		
Carcinoma of floor of mouth	1		
Carcinoma of ear	1		
Lymphosarcoma	1		
Carcinoma of undetermined origin	1	1	
Totals	74	30	13

appearing in roentgenograms lagged far behind the amount of destruction actually present in the bone, and frequently in spines with multiple metastases only one or two were apparent in the roentgenogram.

The earliest microscopic evidence of change produced by the tumor deposits was an infiltration of the marrow spaces; this was particularly well shown in the smaller deposits and at the periphery of the larger deposits. This was followed by reactions in the bone which varied greatly. In some cases there was destruction of the bone spicules, in others fibrosis of the marrow spaces about the tumor, and in many tumors there was slight to marked osteoblastic activity with production of osteoid tissue.

The roentgenograms in some of these latter cases did not show osteoblastic foci. In most sections there was an intermingling of these reactions. In general, fibrosis was minimal in the more rapidly growing tumors; in these, areas of necrosis were frequently encountered. In most cases the microscopic picture of the metastasis conformed closely to that of the primary tumor.

Thus in an analysis of an unselected consecutive series of tumor deaths, the incidence of bone involvement was found to be high (41 per cent.). This is all the more striking when one considers that these cases are from a Veterans Hospital, where tumors of the breast, thyroid, and the female genito-urinary tract are rarely seen. The seventy-four cases include twenty different types of tumor, fourteen of these revealing metastases.

We feel definitely that tumor deposits are more frequently present in bone than is commonly believed. The usual technique of bone examination at autopsy is the taking of one or more wedges of bone from one or more sites. Stein found an incidence of 40 per cent. by taking wedges from numerous sites, and Abrams 27.2 per cent. by taking sections from the thoracic and lumbar spine. We feel that there is an excellent chance of locating tumor deposits by sectioning as large a block of bone as the lumbar vertebral bodies. As this study shows, the spine is a reservoir for metastases from neoplasms arising in many parts of the body.

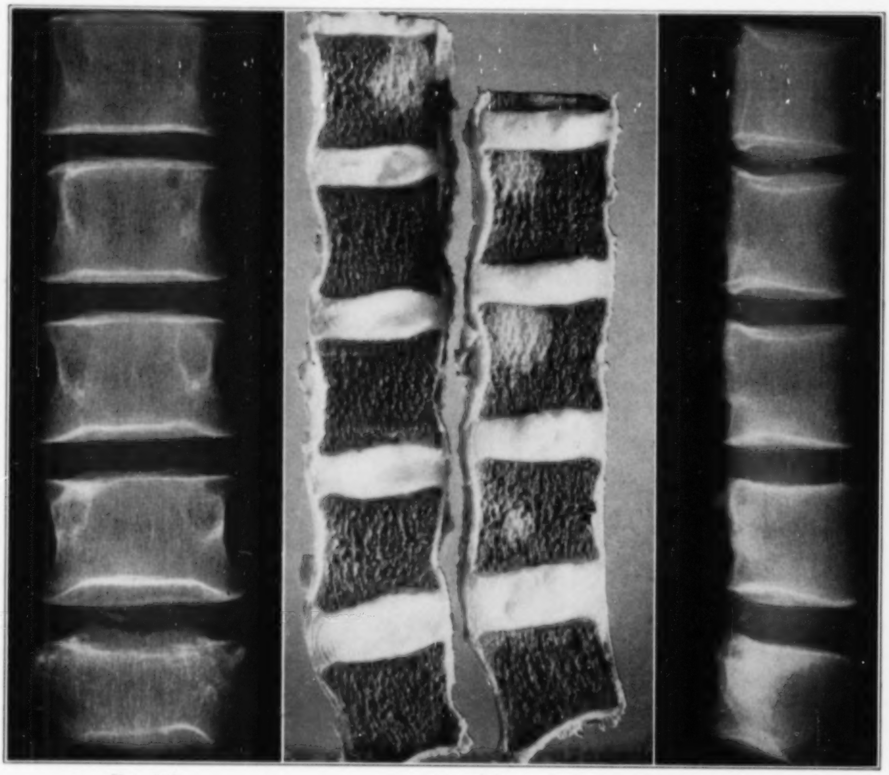

FIG. 6-A FIG. 6-B FIG. 6-C

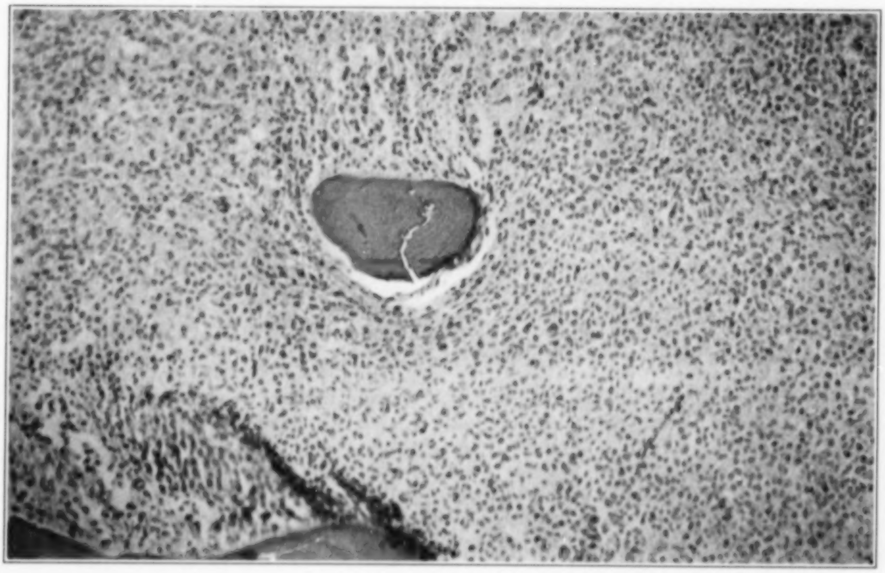

FIG. 6-D (× 52)

Hodgkin's disease: The x-rays show none of the multiple metastases. The microscopic picture is one of infiltration and some destruction.

SUMMARY

Seventy-four consecutive cases of tumor death studied for metastases to the lumbar spine showed an incidence of 41 per cent.

Roentgenographic study of the spines removed from the body revealed lesions in only thirteen of the thirty spines with metastases.

It is believed that adequate examination of bone should be a routine part of every autopsy in tumor death, to determine more accurately the incidence of spread to bone. The skeletal system is more often involved by tumor than is commonly believed.

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DISCUSSION

Osteochondritis Dissecans in Children

(Continued from page 47)

loose body surgically, accepting the fact that irregularity of the joint surface will almost invariably result in early osteo-arthritis.

I believe that this paper has been a real contribution and, if we keep this condition in mind when we examine children, we should recognize more cases during childhood and would begin treatment before permanent damage could occur.

Dr. Don E. King, San Francisco, California: Osteochondritis dissecans, up to this time at least, has been considered a rare disease. What little most of us know of it, we have learned from the observation of late cases. The sequestrum has already dropped out into the joint with the result that mechanical derangement and, in old cases, degenerative joint changes, which inevitably follow, occur. After hearing Dr. Green's paper, one wonders if some of the children who have growing pains, muscle cramps, and transitory limps might actually have osteochondritis dissecans. There probably are many cases in which there never develops the classical x-ray picture of a sequestrum lying snugly within a focus bed. A localized area of spotty subchondral osteoporosis may be the only finding. Some men have previously suggested that this lesion could heal without surgical intervention. As far as I know, Dr. Green is the first to demonstrate this with a satisfactory series of proved cases.

This is a most interesting and instructive paper, contributing much to our scanty knowledge of osteochondritis dissecans.

Dr. Green (closing): I merely want to thank the discussors for being kind, and to mention that Dr. Charles Sturdevant and Dr. George Beattie assisted in the follow-up of these cases. I would like to emphasize, in conclusion, that, as we have observed these patients, we have found healing following protection is much more rapid than one would believe possible.

SHELF OPERATION IN CONGENITAL DYSPLASIA OF THE ACETABULUM AND IN SUBLUXATION AND DISLOCATION OF THE HIP *

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From the Ortopediska Kliniken Lasarettet, Lund

A good reduction of the hip in cases of congenital dislocation is no guarantee of a perfect end result, whether the reduction is obtained by closed or by open methods. On the contrary, the results are perfect in relatively few cases, imperfect in many, and even poor in some.

In this connection I will confine myself to quoting Severin's series of 448 hips in 330 patients treated by closed reduction, and Massie and Howorth's series of 58 hips treated by open reduction [5] (Table I). The method of assessing results was different in the two series, and the functional results were better than the roentgenographic in both, which of course is a well known fact. As Massie and Howorth stress, it is best to take both into consideration.

TABLE I

LATE RESULTS IN TREATED LUXATIONS

Series	Normal (*Per cent. of Series*)	Fair (*Per cent. of Series*)	Unsatisfactory (*Per cent. of Series*)
Massie and Howorth			
58 cases of open reduction			
Symptomatic (Functional)	65.	20.	15.
Physical	39.	34.	27.
Roentgenographic	17.	22.	61.
Severin			
448 hips in 330 patients treated by closed reduction. (6.9 per cent. dead or not traced.)			
Functional	27.6	39.5	26.
Roentgenographic	11.4*	24.6**	57.***

* This represents a combination of Groups I and II in Severin's Table XVI.
** Groups III and IVa in Severin's Table XVI.
*** Groups IVb, V, and VI in Severin's Table XVI.

In the author's opinion, roentgenographic studies are most important, as they will determine the surgeon's attitude to the therapy,—that is, in these cases, to the shelf operation. This is particularly important since most of these patients are children who cannot always give a clear picture of their symptoms.

I shall be using the term *dysplasia*, without and with subluxation, and *luxation*, and it seems necessary to define these terms, as they have a particular significance in the roentgenographic studies.

In an adult, the acetabular roof in a normal hip joint is developed in such a manner that the head of the femur has a good support. During efforts to find a method of determining the normal development of the acetabular roof, I found that an angle, which I called the CE angle[11], could be used.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 29, 1952.

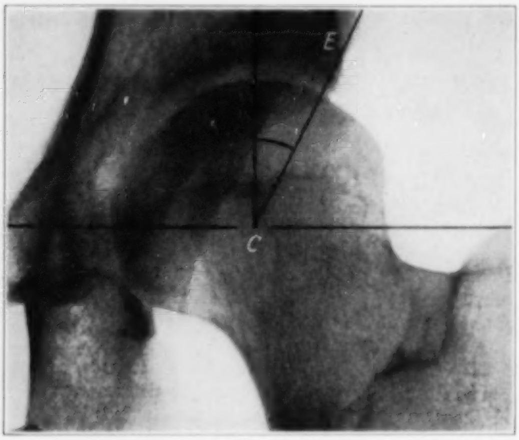

Fig. 1

Roentgenograms showing measurement of the CE angle in an adult hip joint. (Reproduced from Erik Severin: Contribution to the Knowledge of Congenital Dislocation of the Hip Joint. *Acta Chirurgica Scandinavica*, **84**, Supplementum 63: 31, 1941.)

This angle is formed by two lines running from the center of the head, one parallel with the long axis of the body and the other running through the edge of the acetabulum. This angle gives a fair indication of the amount of support which the femoral head gets from the acetabular roof (Fig. 1).

From investigations on normal subjects, consisting of 200 hips—half in men and half in women—I found that values above 25 degrees were normal and values below 20 degrees were pathological. Values between 20 and 25 were uncertain. Thus a CE angle below 20 degrees in an adult means that the acetabular roof is maldeveloped, or dysplastic. If this dysplasia increases, it will allow the femoral head to slip, and subluxation will develop. Such subluxations ordinarily can be recognized by a broken Shenton's line (Fig. 2).

It is much more difficult, however, to make a distinction between *subluxation* and *luxation*. In my opinion one may talk about luxation when the femoral head is completely outside the socket, without any contact with it,—that is, outside the limbus cartilage. As long as there is contact between the head and the socket, one may speak of a subluxation. Actually, this can be determined only with the aid of arthrographic studies, which are relatively difficult to perform on adults, and of necessity subjective factors will always enter into the distinction between subluxation and luxation.

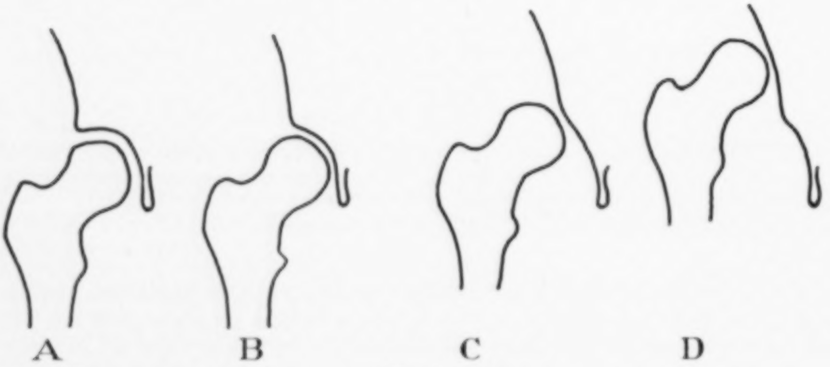

Fig. 2

A: Normal acetabulum. *B:* Dysplastic acetabulum without subluxation. *C:* Dysplastic acetabulum with subluxation. *D:* Luxation (dislocation).

It is also possible with the aid of the CE angle to make a distinction between a normal and a dysplastic joint in children. Severin, Massie and Howorth, and the author have carried out investigations on children. Massie and Howorth [4] found that the method may be used down to three years of age, Severin to six years, and the author to four years. Thus, if the CE angle is below 15 degrees between three and seventeen years, the condition must be called dysplasia.

TABLE II

NUMBER OF HIPS SHOWING OS ACETABULI IN A SERIES OF 642 HIPS BETWEEN THE AGES OF ONE AND SEVENTEEN YEARS

Age (*Years*)	Number Girls	Number Boys	Total
11 to 12	4	0	4
12 to 13	4	2	6
13 to 14	2	1	3
14 to 15	1	2	3
15 to 16	2	3	5
16 to 17	0	2	2
Total	13	10	23

I am therefore of the opinion that the development of the acetabular roof, and especially of the lateral rim of the roof, is very important, and for this reason I have paid special attention to the development of the lateral rim in normal as well as in dislocated hip joints.

Anatomical and roentgenographic studies have shown that the so-called ossa acetabuli—the small accessory ossification centers lying within the rim of the acetabulum—play a part in the development of the acetabulum. There is some difference of opinion about the number of accessory bones concerned. The author agrees with Perna that there are three distinct types of ossa acetabuli: anterior, superior, and posterior (Fig. 4). In the roentgenogram they have the appearance which is shown in Figures 5-A, 5-B, 6, and 7.

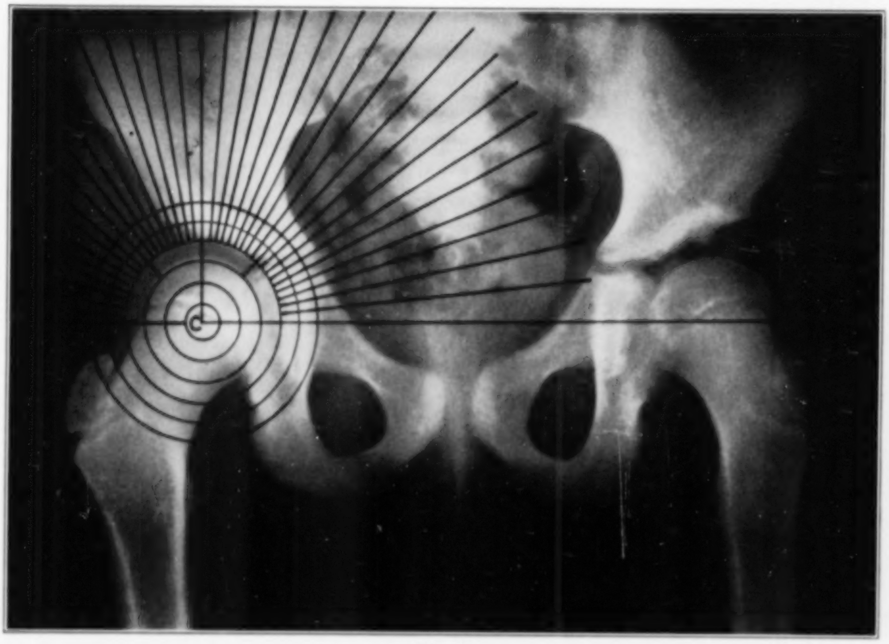

FIG. 3

Method of measuring the CE angle. The angles and concentric circles are drawn on a celluloid plate. The concentric circles are placed over the head, so that the outline of the head is parallel with the circles and the horizontal line passes through the center of the contralateral head. The CE angle can then be read directly.

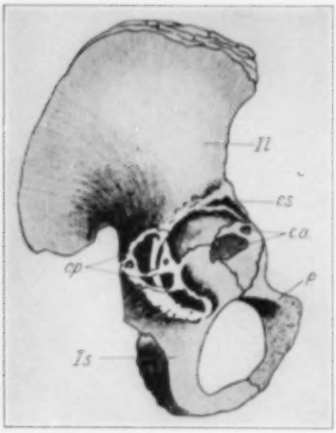

FIG. 4

Ossa acetabuli according to Perna: *c.a.*, os acetabuli anterius; *c.s.*, os acetabuli superius; *c.p.*, os acetabuli posterius. (Reproduced from Giovanni Perna: Sulla ossificazione dell' acetabulum e sul significato del tuberculum supracotyloideum nell' uomo. *La Chirurgia degli Organi di Movimento*, **6**: 506, 1922.)

The time of their appearance is the matter of interest. The author therefore examined 642 hips (Table II) in subjects between the ages of one and seventeen years.[12] No os acetabuli was found in the age group below eleven years. All twenty-three hips showing such a bone were in the group eleven through seventeen years.

In the follow-up roentgenograms of patients with reduced dislocations it is sometimes possible to find ossification centers lying near the upper lateral rim. These appear early, as was pointed out by Francillon, who reported one case of ossification centers occurring in a patient aged three years. I have studied 100 cases of treated congenital dislocation to investigate the appearance of these centers.[12] The centers are at first very diffuse, but as they enlarge they become clearer (Figs. 8-A to 9-F). All these patients had, in accordance with our routine treatment of congenital dislocation, been followed roentgenographically for many years and each had had an average of fifteen separate roentgenographic examinations. Eighty-five patients were female and fifteen were male; this corresponds with the usual sex incidence. In seventy-six cases the reduction had been done before the patient was three years old. Ossification centers were detected in no less than sixty-two of the 100 cases, and in most of these they appeared considerably earlier than the ossa acetabuli mentioned above. Table III shows that such centers were present in nine patients between two and three years of age and in twenty-nine below the age of four. After the seventh year their appearance was more sporadic.

In view of the fact that these centers appear at a quite different and earlier age period from that of the ossa acetabuli, I consider that one must allow them a quite independent character, unrelated to the normal accessory ossification centers, and I have regarded the term "ossification centers in dislocations" as more appropriate. The cause of the development of these centers is of course an interesting question, but one can give only a hypothetical answer. One might consider that a previously subluxated or luxated

TABLE III

AGE AT WHICH THE ACCESSORY CENTERS OF OSSIFICATION APPEARED IN SIXTY-TWO OF ONE HUNDRED CASES OF TREATED LUXATIONS

Age (*Years*)	Number		Total
	Girls	Boys	
2 to 3	7	2	9
3 to 4	19	1	20
4 to 5	10	0	10
5 to 6	11	1	12
6 to 7	3	3	6
7 to 8	0	0	0
8 to 9	2	0	2
9 to 10	0	2	2
10 to 11	1	0	1
Total	53	9	62

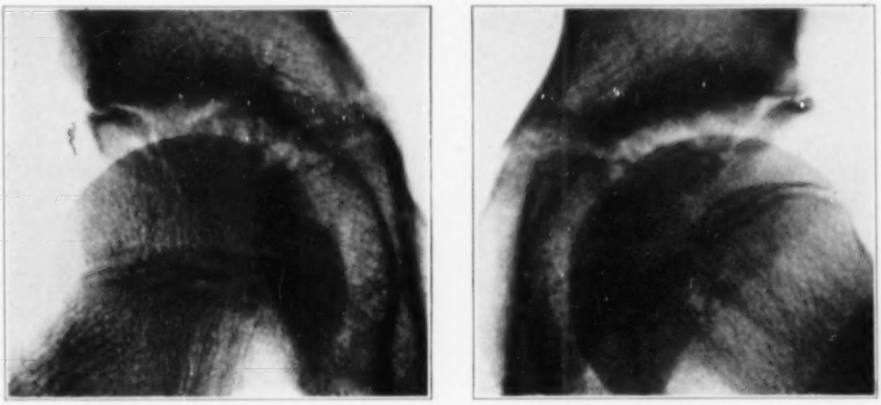

Fig. 5-A Fig. 5-B

Ossa acetabuli in a girl aged twelve years.

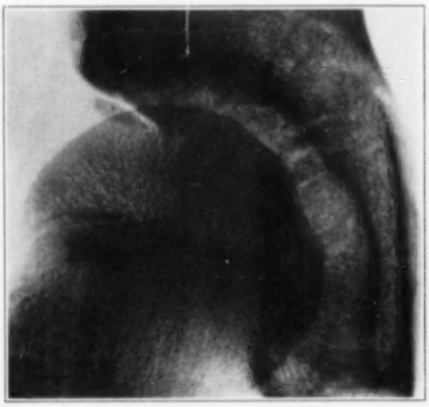

Fig. 6

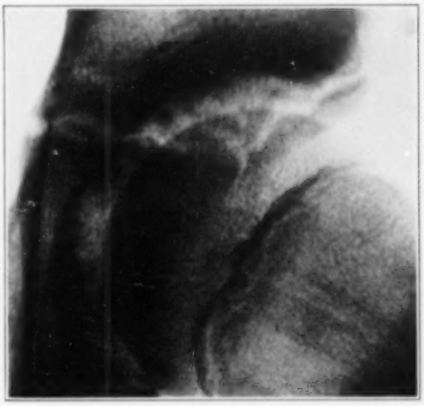

Fig. 7

Fig. 6: Ossa acetabuli in a boy aged twelve years.

Fig. 7: Ossa acetabuli in a boy aged fifteen years. (Figs. 5-A through 7 reproduced from Gunnar Wiberg: Pfannendachplastik bei Dysplasia Acetabuli, Subluxatio und Luxatio Coxae, unter besonderer Berücksichtigung der Entwicklung des oberen Pfannenrandes. *Archiv für Orthopädische und Unfall-Chirurgie*, **43:** 314–369, 1944.)

femoral head might in some way, perhaps by pulling on the attenuated capsule, exert pressure on the upper acetabular rim and so hinder its development. This might cause an increase in the growth tendency of the rim after removal of this restriction by replacement of the head and thus make the development of these centers possible.

What is the significance of these ossification centers for the later shape of the ace-

TABLE IV

The CE Angle in One Hundred Cases of Treated Luxations

	Cases with Ossification Centers	Cases without Ossification Centers
Number of Cases	62	38
CE angle positive	61 per cent.	31 per cent.
CE angle negative	39 per cent.	69 per cent.

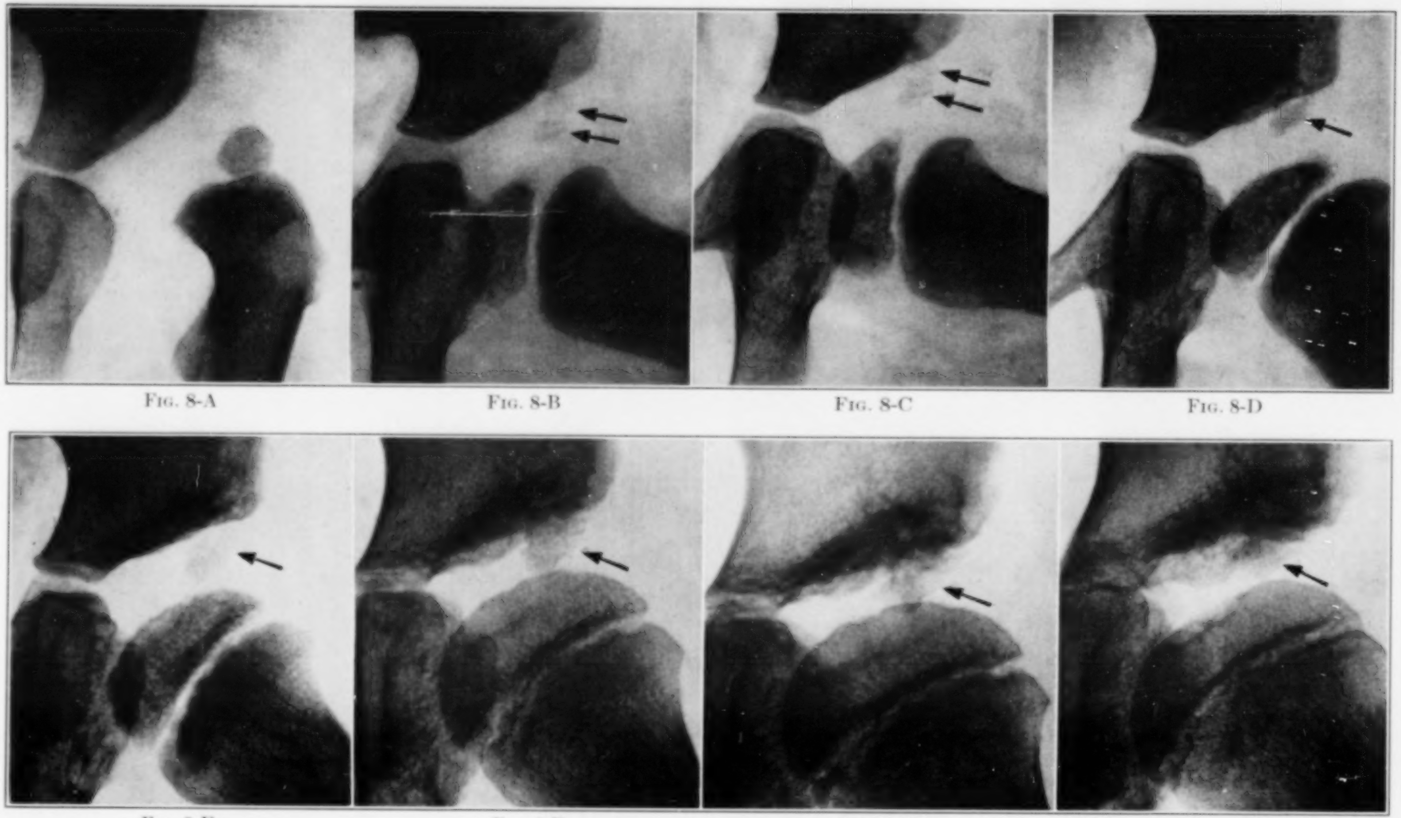

FIG. 8-A FIG. 8-B FIG. 8-C FIG. 8-D

FIG. 8-E FIG. 8-F FIG. 8-G FIG. 8-H

Fig. 8-A: In this case, the dislocation was reduced when the patient was fourteen months old.
Fig. 8-B: Seven months after the reduction, an ossification center appeared.
Figs. 8-C to 8-H: The center enlarged and finally fused with the acetabular roof. Fig. 8-H was made four years after the reduction.

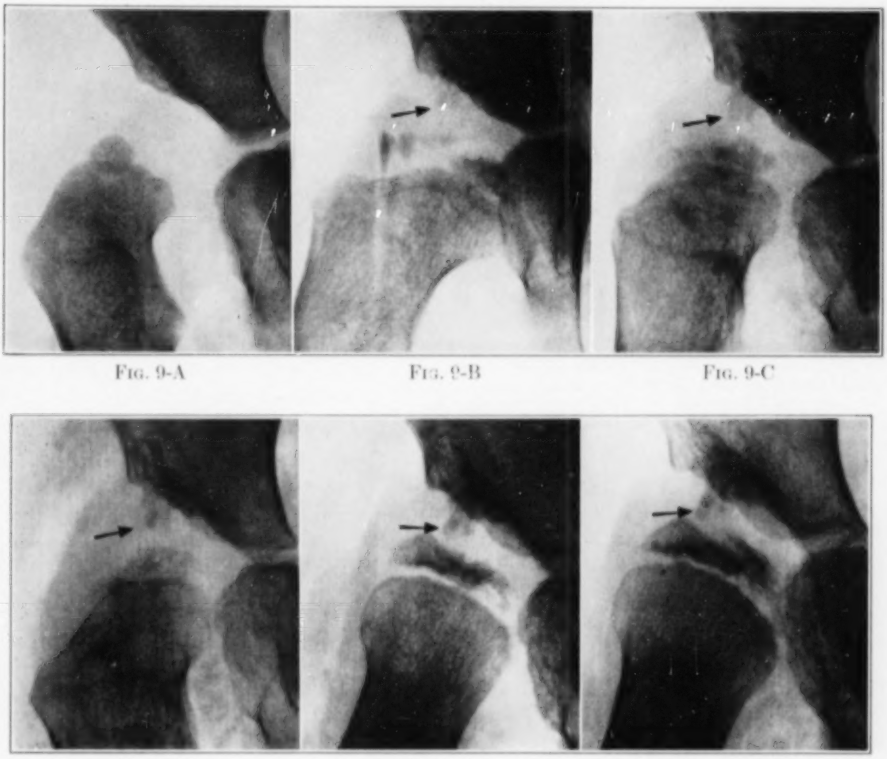

FIG. 9-A FIG. 9-B FIG. 9-C

FIG. 9-D FIG. 9-E FIG. 9-F

Fig. 9-A: The roentgenogram shows a congenital dislocation which was reduced when the patient was eighteen months old.

Fig. 9-B: Seven months after reduction an ossification center had appeared.

Figs. 9-C to 9-F: The center enlarged and finally fused with the acetabular roof. Fig. 9-F was made two years after reduction. (Figs. 9-A through 9-F reproduced from Gunnar Wiberg: Pfannendachplastik bei Dysplasia Acetabuli, Subluxatio und Luxatio Coxae, unter besonderer Berücksichtigung der Entwicklung des oberen Pfannenrandes. *Archiv für Orthopädische und Unfall-Chirurgie*, **43:** 314–369, 1944.)

tabulum? This has been studied by examining the CE angle in the sixty-two patients just mentioned at later dates (Table IV). Since these patients were not all followed during exactly the same age periods, I have not recorded the exact CE angle, but instead merely observed whether it had a negative or a positive value. I found that sixty-one per cent. of the sixty-two patients who had ossification centers had positive CE-angle values. In the remaining thirty-eight cases without ossification centers the CE angle was positive in only 31 per cent. It is therefore clear that these ossification centers have a definite significance for the future shape of the acetabular roof. In the few cases in which they appeared after seven years, the fate of the acetabulum had to a certain extent already been decided. This may explain Massie and Howorth's observation [5] that the years five through eight are a critical period in the development of the acetabulum.

The practical significance of these ossification centers in dislocations is that they give some possibility of estimating the prognosis for the acetabulum in this age group; this will affect one's attitude toward shelf operations.

When poor results are obtained in cases of closed or open reduction some further treatment is necessary; this applies also to untreated primary subluxations coming to treatment at a later age. It is well known that these defective joints have a tragic fate if

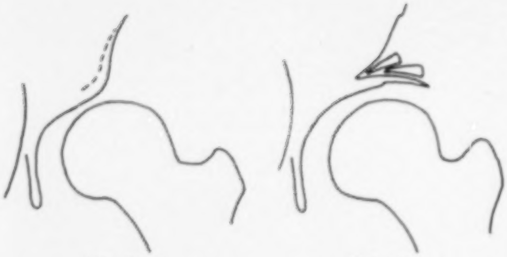

FIG. 10-A FIG. 10-B

Schematic drawing of the technique of shelf operation used in the earlier cases. Fig. 10-A shows the chiseling above the margin of the acetabulum. Fig. 10-B shows the roof pulled down and the bone grafts wedged in above it. (Reproduced from Gunnar Wiberg: Studies on Dysplastic Acetabula and Congenital Subluxation of the Hip Joint. *Acta Chirurgica Scandinavica*, **83**, Supplementum 58: 120, 1939.)

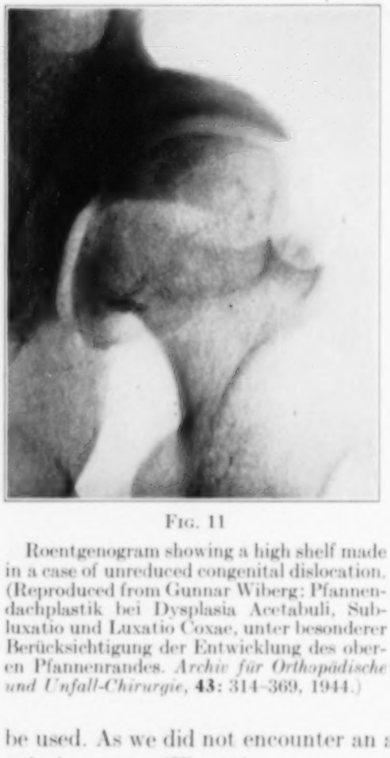

FIG. 11

Roentgenogram showing a high shelf made in a case of unreduced congenital dislocation. (Reproduced from Gunnar Wiberg: Pfannendachplastik bei Dysplasia Acetabuli, Subluxatio und Luxatio Coxae, unter besonderer Berücksichtigung der Entwicklung des oberen Pfannenrandes. *Archiv für Orthopädische und Unfall-Chirurgie*, **43**: 314–369, 1944.)

left untreated. The reduced area of supporting surface in such a joint implies an increased burden on the joint cartilage, and this in its turn causes cartilage degeneration and osteo-arthritis deformans. I have studied a series of 257 hips with osteo-arthritis deformans and have found that not less than 25.7 per cent. of them were caused by dysplasia or subluxation.

Of the operations suggested to give further protection in these cases, shelf operations have come to adopt a dominant position.

Shelf operations have been shown to be very satisfactory; they are an accepted method of treatment and there have been a number of reports showing their value.

A number of modifications have been made on the two main methods of shelf operation, Albee's and Spitzy's. I do not wish to discuss here the advantage of one method over the other. In Sweden, for a number of reasons, we have come to adopt the modification of Albee's method which Gill described in 1935.

The procedure of the operation has been the following:

A thin slice of cortex about one by two centimeters is chiseled off from the wing of the ilium and bent down from the border of the acetabular roof. The chiseling is begun parallel to the surface of the cortex and, as one approaches the roof, is directed more medially (Figs. 10-A and 10-B). The gap made by the chiseling is packed with bone chips taken from the outer surface of the iliac crest; these must extend sufficiently far to support the thin ledge of cortex. In this way the new support for the head is formed mainly of cortex.

In some cases of dislocation and in cases of marked subluxation, a different technique had to be used. As we did not encounter an acetabular rim, the new acetabular roof was formed only by cortex (Fig. 11).

The patients in the author's series were operated on during the years 1938 through 1950 and the period of follow-up was at least one year, in most cases much longer. The series consists of eighty-five cases; seven cases of luxation, sixty-seven cases of subluxation, and eleven cases of dysplasia. Most of these were dislocations which had been treated, but there were also some cases of untreated dislocation and subluxation (Table V).

As there have been a number of reports on the results of shelf operations and as all have shown that the method is very useful, this report will not attempt to offer a detailed description of the results in terms of fatigue, limp, pain, restricted mobility, Trendelenburg

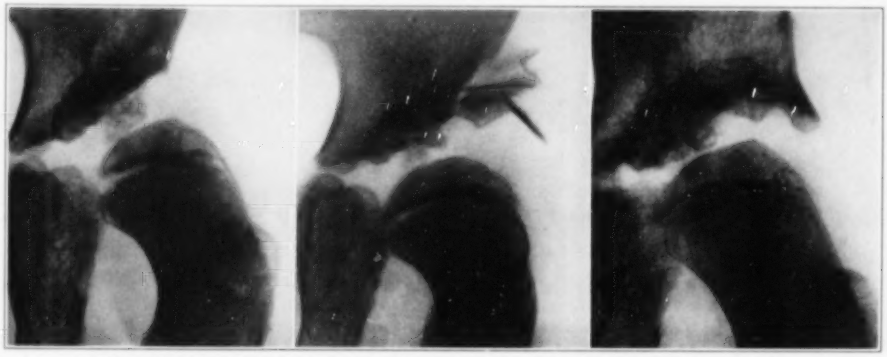

FIG. 12-A FIG. 12-B FIG. 12-C

Gill's shelf operation, as used in the earlier cases in this series.

Fig. 12-A: Before operation.

Fig. 12-B: A thin slice of cortex is chiseled down and three small bone grafts taken from the iliac crest are placed in the space.

Fig. 12-C: Roentgenogram made three years after operation. (Figs. 12-A to 12-C reproduced from Gunnar Wiberg: Pfannendachplastik bei Dysplasia Acetabuli, Subluxatio und Luxatio Coxae, unter besonderer Berücksichtigung der Entwicklung des oberen Pfannenrandes. *Archiv für Orthopädische und Unfall-Chirurgie*, **43**: 314–369, 1944.)

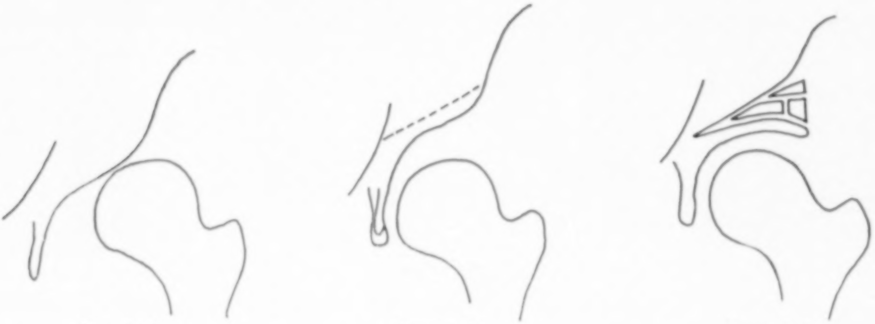

FIG. 13-A FIG. 13-B FIG. 13-C

Schematic drawing of the shelf operation used in the later cases.

sign, and other factors. It should be pointed out, however, that all these symptoms have been considered in evaluating the results.

Only two of the seven patients with dislocation treated by shelf operation were young children; they were three and four years old respectively. The others were eight or more years of age. It may appear strange that only two cases of shelf operation performed at the same time as the reduction are reported, since the routine method of many surgeons is to combine the two procedures. It is therefore necessary to explain this small number.

TABLE V

RESULTS OF OPERATION IN RELATION TO TYPE OF INVOLVEMENT

Type of Involvement	Excellent	Good	Improved	Not Improved	Worse	Total
Dysplasia	1	9	0	1	0	11
Subluxation	13	35	14	5	0	67
Luxation	1	1	2	2	1	7
Total	15	45	16	8	1	85

Our present routine procedure is the following: In all patients aged two to three years with congenital dislocation, a closed reduction is attempted first. Our reductions are done according to the method of Lorenz and, after reduction, both hip joints are put in plaster in the frog position, — that is, 90 degrees of flexion and about 70 degrees of abduction. The plaster does not extend below the knees. After three months the plaster is removed and the children then use a wooden case, which is in the same shape as the posterior part of the plaster, so that they are able to rest with relative comfort. This case is used during the night as well as for daytime naps.

If this method proves unsuccessful, an open reduction is performed but *without addition of a shelf operation*. The patient is then followed by regular roentgenographic control

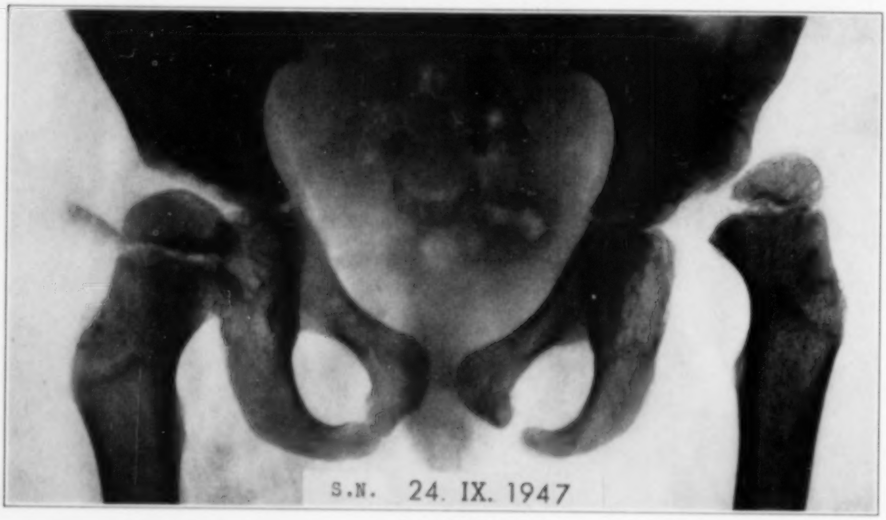

FIG. 14-A

S. N., female, aged five years. Roentgenogram made on September 24, 1947, showed subluxation on the left side.

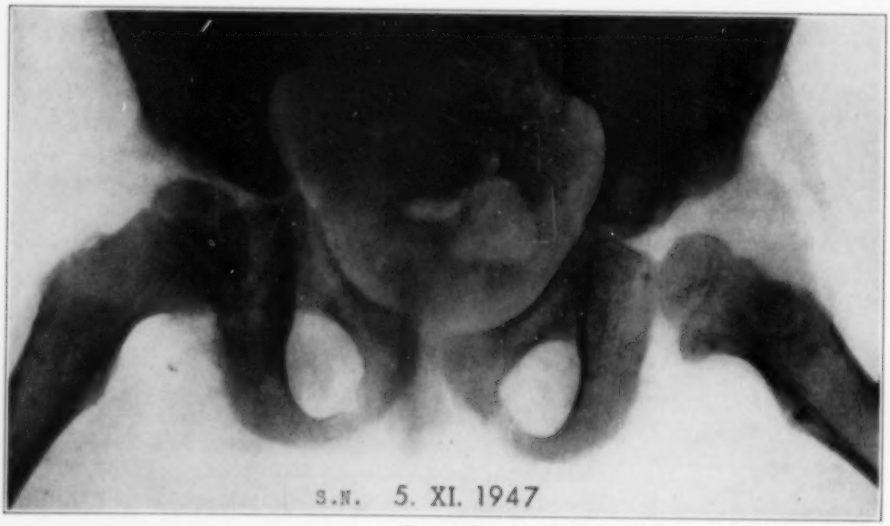

FIG. 14-B

Roentgenograms made November 5, 1947, after slow reduction.

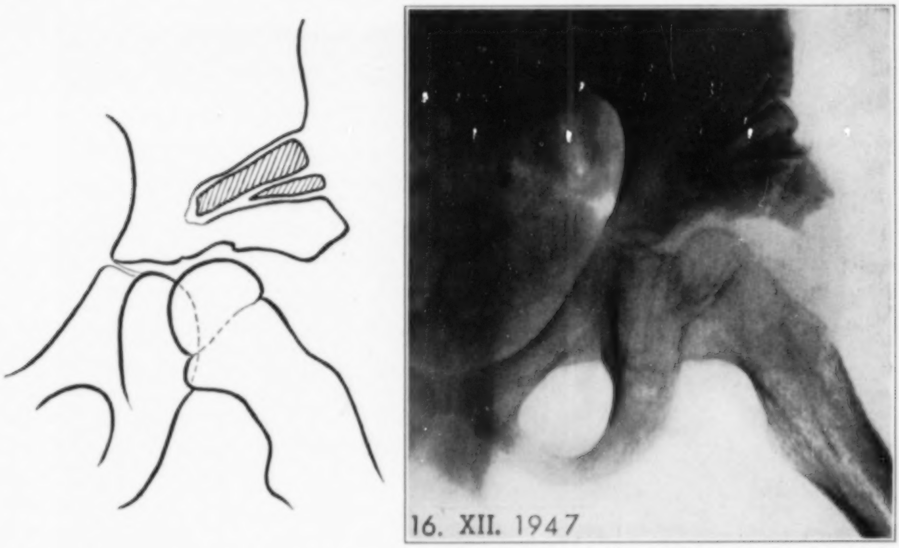

FIG. 14-C

Roentgenogram made December 16, 1947, immediately after shelf operation. Drawing shows procedure now in use. (Figures 14-A to 14-C reproduced from Gunnar Wiberg: Reduction and the Shelf Operation in Over-Age Dislocations. *Acta Orthopaedica Scandinavica*, **21**: 33, 34, and 35, 1951.)

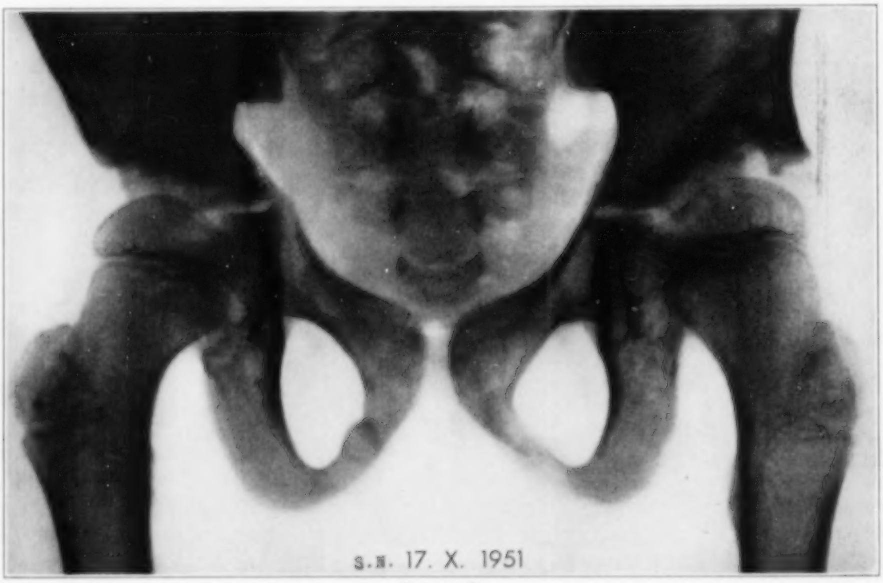

FIG. 14-D

Roentgenogram made October 17, 1951, four years after operation, when the patient was nine years old.

for many years. Only when there is a redislocation or when the development of the acetabular roof appears to show a tendency to be defective and there is an associated tendency to subluxation of the head, do we perform a shelf operation. Thus, both the patients mentioned above were exceptions to this routine. They were operated on in 1938, before we had established our indications for shelf operation. I should add that the result in the

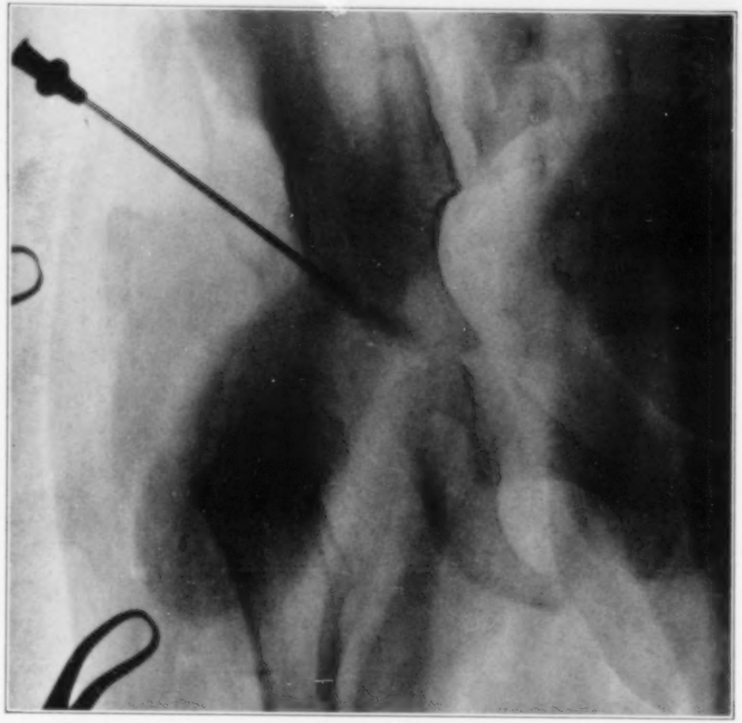

Fig. 15-A

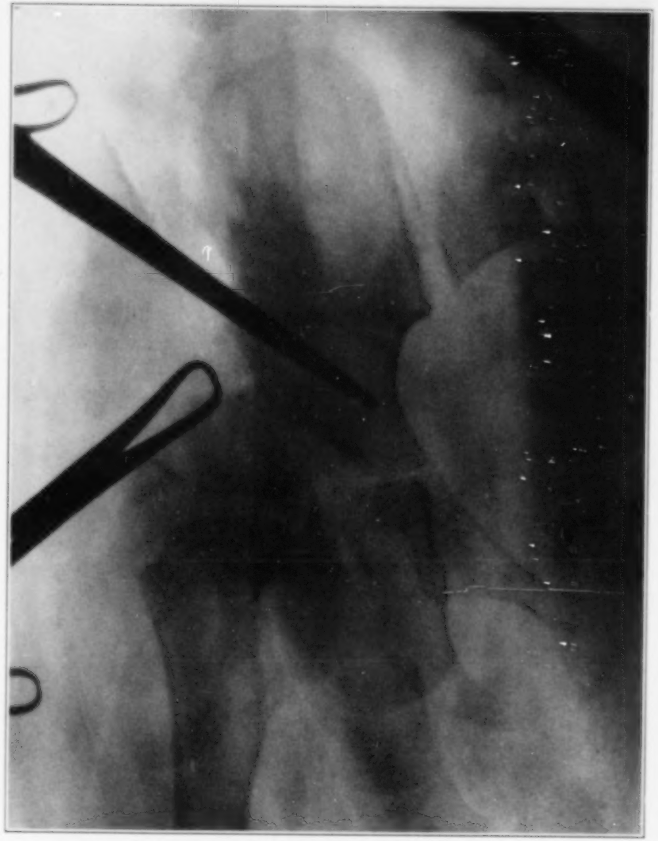

Fig. 15-B

Fig. 15-A: The aspiration needle has been placed in the joint as an indicator to show where the chiseling should begin on the lateral part of the acetabular roof.

Fig. 15-B: Roentgenogram made to control the position of the chisel before the shelf is turned down.

TABLE VI

Results of Shelf Operation for Subluxation in Relation to Age at Operation
(Sixty-seven Hips)

Age (*Years*)	Excellent I	Good II	Improved III	Not Improved IV	Worse V	Total
5 or under	3	9	1	1	0	14
6 to 10	6	11	3	0	0	20
11 to 20	2	9	5	1	0	17
21 or over	2	6	5	3	0	16
Total	13	35	14	5	0	67

child aged four years was good, while in the child aged three years the shelf was absorbed and a new shelf operation had to be performed five years later.

The remaining five patients were all over eight years, so that we did not dare to attempt a reduction, but in order to help the patient as far as possible we performed a so-called high shelf operation: a roof was made, but the position of the head was not altered. This diminished the patient's symptoms, and I think it is right to use this method in these old cases of dislocation. Any attempt at reduction over the age limit of seven to eight years carries the risk of necrosis of the femoral head.

Table V shows that the results in the sixty-seven cases of subluxation were satisfactory: forty-eight, or 71 per cent. were included in the first two groups (those with excellent or good results). These results correspond roughly with those reported by other workers.

As I have been interested in the effect of the patient's age on the results in cases of subluxation, I have shown the age of the patients at the time of operation (Table VI). Although the number of cases is relatively small, there does appear to be a predominance of good results in the age groups below eleven years. Not less than twenty-nine, or 85 per cent., of the thirty-four hips operated upon below eleven years of age were in Groups I and II (those with excellent or good results), as compared with forty-eight, or 71 per cent., of the total sixty-seven cases. Meiss made the same observation; he found that he obtained good results in 75 per cent. of patients aged six through ten years, as compared with 66 per cent. of all cases.

The eleven patients who had dysplasia without subluxation, most of whom were adults, had mainly good results. Looked at superficially, this appears to be reasonable, since in these cases the defect is less. In the author's experience, however, dysplasia is as difficult to operate on as subluxation, if not more so, for the following reason:

In cases of subluxation, the femoral head tends to slide laterally and upwards and, even if a new roof does not at first give a perfect support to the head, such support will be obtained after a further insignificant degree of slipping.

If, on the other hand, there is dysplasia without subluxation, the head shows very little tendency to slide, and relief of the insufficiency of the joint which is causing the patient's symptoms demands that the new roof shall be effectively in contact with the vertex of the femoral head. In fact, these cases exact a greater surgical experience than the others since, if placed too high, the new roof will make no difference to the joint and, if placed too low, it will cause a pressure necrosis of the joint capsule and resulting stiffness.

In the present series of eighty-five cases, there have been no deaths and few complications: a postoperative thrombosis in one case, which had no serious consequences; a superficial wound infection, which did not affect the joint; and meralgia paraesthetica in one case, which responded to surgery. The results might be interpreted as completely satisfactory. It should be possible, however, to obtain better results in cases of subluxation if the head is brought into the correct position. If the head is replaced into the socket, more effective support from the shelf is needed, and this is made more certain if the roof is brought down entirely than if, as in the older methods, it is formed mainly from the reflected slice of cortex. Accordingly, the technique was altered so that most of the acetabular roof was brought down. Figures 13-A to 13-C show the technique of chiseling employed in these cases, and the following reports will also illustrate the method employed.

The first was a case of previously untreated subluxation.

This was a girl, aged five years, who on admission had a subluxation of the left hip (Fig. 14-A), 1.5 centimeters shortening of the leg, a positive Trendelenburg sign, and a marked limp. Part longitudinal and part medial traction resulted in reduction after five weeks (Fig. 14-B), and the hip was operated on by the method described while the traction was maintained (Fig. 14-C). After the operation, plaster was applied

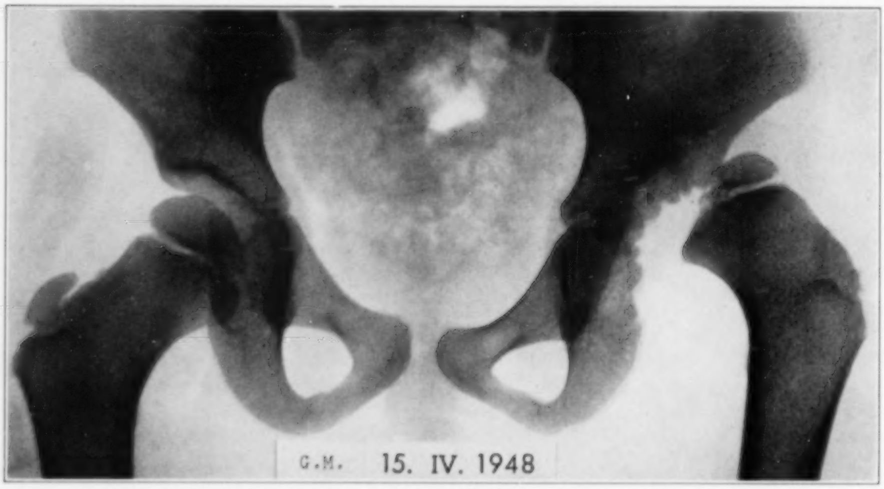

FIG. 16-A

G. M., female, aged four years. Roentgenogram made April 15, 1948, showed subluxation on the left side. (Reproduced from Gunnar Wiberg: Reduction and the Shelf Operation in Over-Age Dislocations. *Acta Orthopaedica Scandinavica*, **21**: 37, 1951.)

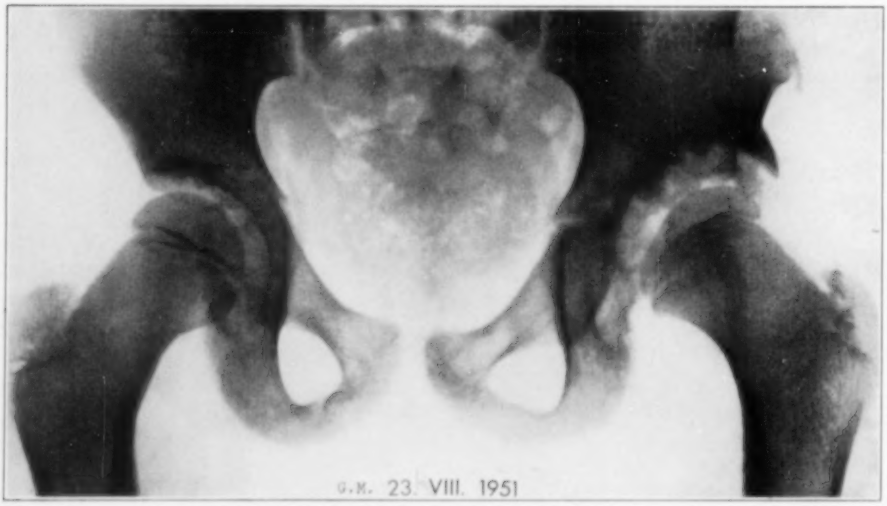

FIG. 16-B

Follow-up roentgenogram made four years after operation, on August 23, 1951, when the patient was eight years old.

with the limb in abduction and was left on for six weeks. The result four years after the operation is shown in Figure 14-D. The patient was completely symptom-free; there was no shortening, no limp, and the Trendelenburg sign was negative. The range of movement was perfect.

There is one detail of the operative technique which it seems important to stress. The chiseling medially should run relatively near to, and parallel with, the roof, so that the part which has to be turned down is not too thick, as this may make it both difficult and dangerous. I think it is best to ensure that the chiseling is begun in the right direction and at the right place by using some method of localization, such as an aspiration needle and roentgen control (Fig. 15-A). Another roentgenogram may be made after the chisel has been driven in (Fig. 15-B).

Another patient presented much the same picture (Fig. 16-A).

The subluxation in a girl, aged four years, was reduced after six weeks of preoperative traction, and operation was then performed. Four years later (Fig. 16-B) the girl, then aged eight years, denied symptoms in the hip; there was one centimeter of shortening as compared with two centimeters preoperatively. The Trendelenburg sign was just positive. There was slight wasting of the left thigh.

One further operative detail is perhaps worth pointing out: If the operation is performed by this method, the large gap created by the turning down of the roof demands a relatively large bone graft. If all this bone is taken from the iliac crest, there will be a considerable defect which, later in life, appears as a marked deformity. Although this may not affect the function of the joint, it is possible to avoid this deformity by using bone from a bone bank, and this is a facility of which we may now make use.

So far we have operated on only fifteen patients in this way, obtaining reduction by slow traction and then turning down the entire roof. In most of these cases it is still too early for a follow-up report, but both the early and the few late results suggest that this method is more successful than that used earlier, and I now use it as the routine procedure in suitable cases.

The question of the age at which the shelf operation should be performed has been discussed, since published series have shown that good results can be obtained both in small children and in older subjects. In this series, the cases of subluxation appear to show that the results are better if the operation is performed early.

It would be desirable to set out exact indications for shelf operations. While these cannot be stated dogmatically, the author wishes to stress these general points:

Reduction of a dislocation often results in a subluxated or dysplastic hip, which in turn is the basis of arthrosis deformans changes if left untreated. I therefore believe that one is bound to complete the treatment with a shelf operation, which ought to reduce the risk of arthrosis deformans, since it increases the support for the head. The operation should be performed early, preferably during childhood, as this seems to give better results, and before the development of degenerative changes in the cartilage, since these will considerably reduce the value of a shelf operation.

There is one further reason in favor of early operation. When one operates on children, one is working with a plastic and adaptable skeleton which not only makes it easier than in an adult, but also gives a better roentgenographic and anatomical result.

In addition, one can make the following more exact statements:

1. In patients with dislocations who are over the age limit, reduction may be attempted up to the sixth or seventh year together with a shelf operation. After that time it is better to do a high shelf operation because of the risk of necrosis in the femoral head.

2. Patients who have been treated either by closed or by open reduction but *whose hips tend to redislocate immediately after treatment must be operated on at once.* Traction followed by the shelf operation is again the procedure recommended. If there is marked anteversion, it may be necessary to do a rotation osteotomy before or after the shelf operation.

3. Patients whose dislocation has been reduced but who *at later roentgenographic*

follow-up show a tendency to subluxation should also be operated upon (traction and shelf operation), if under seven years of age.

4. The cases in which it is most difficult to decide on the method of treatment are those in which there is definite dysplasia but no subluxation. I think it is best to adopt an expectant attitude in these cases and to follow them carefully. If at the "critical age" for the acetabulum (seven or eight years) there are even slight symptoms, operation should be favored.

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MANAGEMENT OF THE CONTRALATERAL HIP IN SLIPPED CAPITAL FEMORAL EPIPHYSIS *

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Nailing with a triflanged nail has been widely accepted as the treatment for slipping of the capital femoral epiphysis if the slipping is minimal, that is, less than one centimeter. It is not excessively difficult for a surgeon who is trained and experienced in nailing fractured hips to nail *in situ* a capital femoral epiphysis with minimal slipping. If the slipping is marked, however, that is, one centimeter or more, it can be a difficult test of the surgeon's ability and experience when he tries to replace the epiphysis (after osteotomy through the epiphyseal plate) to its anatomical position before nailing. Some orthopaedic surgeons, therefore, after taxing experiences with the open operation, have been inclined to look with trepidation at minimal slipping in the contralateral hip which might eventually become marked and require another such operation. They earnestly propose that slipping in the contralateral hip, even if it is still asymptomatic, should be treated by nailing as soon as it is recognized, at a time when nailing *in situ* is still an adequate measure. Such dogma warrants further consideration to determine whether it is common sense.

In our earlier papers we reported an incidence of about 20 per cent. of contralateral slipping, with attendant symptoms, which required nailing. Since "normal" standards have become available [1] for comparison with the hip roentgenograms of patients followed for treatment of unilateral slipping, we now have the means of detecting contralateral slipping as soon as it appears roentgenographically, and before subjective symptoms are experienced. It therefore seemed advisable first to review all our cases and to compare them with "normal" hips to determine the frequency of occurrence of contralateral slipping; and next to uncover the number of those patients with slipping who had to be operated on and the number of those who escaped operation without irreparable damage. It was hoped that during this investigation pertinent early roentgenographic signs might be detected which would point to later need for nailing. Then it might be possible to conclude whether indiscriminate nailing of contralateral slipping is justified or whether it is preferable to wait for subjective symptoms before nailing.

This report is based on sixty-eight patients with eighty-one slipped capital femoral epiphyses treated at the Massachusetts General Hospital from 1933 to 1949. Thus about four patients appear every year at the Out-Patient Department for treatment of their slipped epiphyses. Since about 800 new patients are admitted annually to the Department, only about 0.5 per cent. of the patients seen there are the basis of our study. They are in fact a rather small group, perhaps too small in number to furnish statistically significant figures. But since they have been meticulously checked in our follow-up clinics for at least two years after slipping occurred and their x-rays have been compared with those of "normal" hips, they are at this time the best source of statistics. From them inferences at least may be drawn and followed profitably until an investigator with a larger series presents different opinions which carry more weight.

Twenty-five, or 41 per cent., of the sixty-one patients we were able to review at this time † had bilateral slipping of the capital femoral epiphysis. There were about five times as many boys as girls. The boys were eleven to sixteen years of age when seen for slipping

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† In seven of our sixty-eight cases films had been discarded because of "fire laws" and were not available for this review.

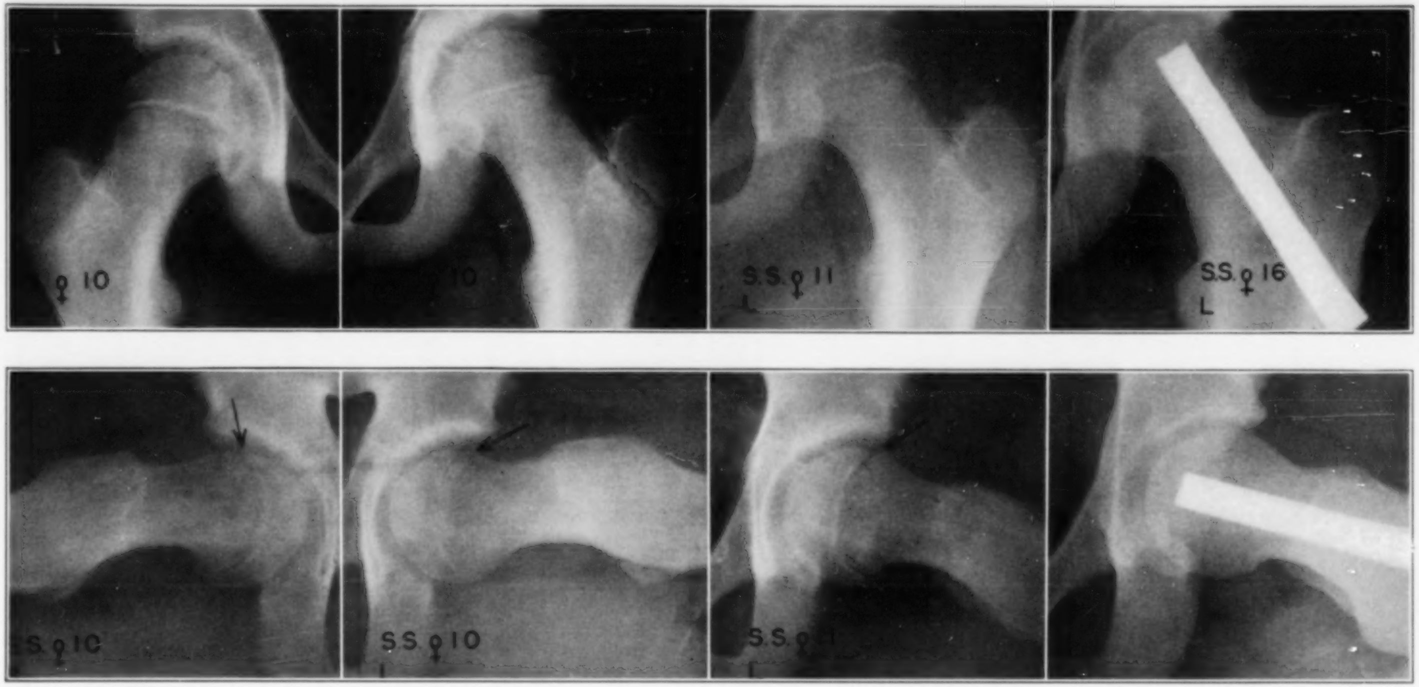

Fig. 1-A
Ten years

Fig. 1-B
Ten years

Fig. 1-C
Eleven years

Fig. 1-D
Sixteen years

Minimal contralateral slipping treated by nailing *in situ.*

Fig. 1-A: S. S., girl, ten years old. Minimal slipping in the right hip indicated by arrow in the lateral view.
Fig. 1-B: At this time the left hip was normal.
Fig. 1-C: Roentgenograms of the left hip one year later. Minimal posterior slipping indicated by arrow in the lateral view.
Fig. 1-D: Roentgenograms of the left hip five years after nailing *in situ.*

in the first hip and averaged thirteen and two-thirds years. The girls were ten to thirteen when they first appeared and their average age was eleven and one-half years.

We reviewed sixty-one patients of whom forty-seven, or 77 per cent., were males and fourteen, or 23 per cent., were females. Twenty-five patients, or 41 per cent., had bilateral slipping of the capital femoral epiphysis. Twenty-one, or 84 per cent., of the latter group were boys and four, or 16 per cent., were girls. Apparently primary slipping of the capital femoral epiphysis and later contralateral slipping occurs at practically the same ratio, that is, much more often in boys than in girls. This is undoubtedly due to the greater stresses and strains placed on boys' hips in their more strenuous physical activities. Omitting from consideration the eight boys who had bilateral slipping treated at their first admission, we have analyzed the protocols of seventeen children with contralateral slipping. Of this group of seventeen, only two patients required open operation for the contralateral hip. In nine patients, symptoms of minimal slipping in the opposite hip developed while they were under observation; these were treated by nailing *in situ* (Figs. 1-A to 1-D).

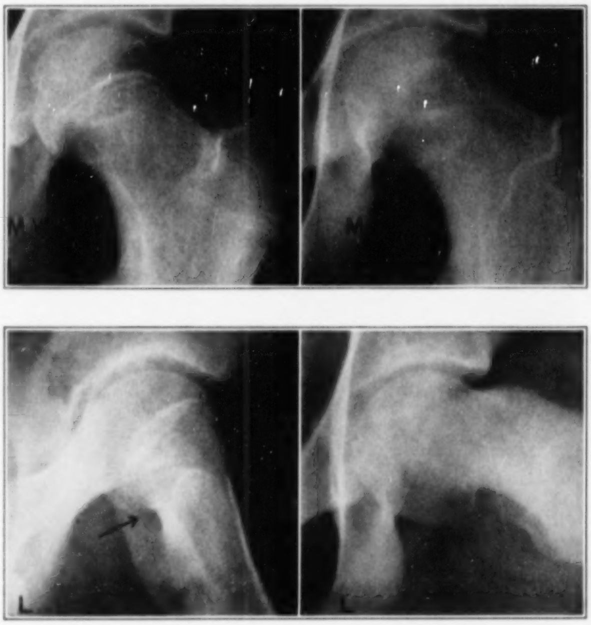

Fig. 2-A
Thirteen years

Fig. 2-B
Fifteen years

M. W., girl. Minimal asymptomatic contralateral slipping was unrecognized. The right hip, not shown, was treated by open reduction and nailing for marked slipping.

Fig. 2-A: In the anteroposterior view of the left hip the superior neck line, if it were projected medially, would cut off a substantial portion of the head. The posterior contour of the head was visible, superimposed on the proximal portion of the neck. These features are indications of posterior slipping. The arrow in the lateral view indicates posterior slipping.

Fig. 2-B: Roentgenograms showing untreated slipping two years later. The epiphysis and the neck have fused. Note the hump on the anterosuperior aspect of the neck.

Six children were not operated on; they were without symptoms. The diagnosis of contralateral slipping in this group became evident only upon comparison of their roentgenograms with those of "normal" hips (Figs. 2-A and 2-B).

Three boys had asymptomatic contralateral slipping, but, after a fall from a haymow in one case and from approximately the same height in the others, were immediately disabled by marked slipping. Two required open operation with osteotomy through the epiphyseal plate, replacement of the epiphysis to its anatomical position, and nailing (Figs. 3-A to 4-D). The third boy's contralateral slipping, although marked, was successfully reduced by closed manipulation and nailed *in situ* (Figs. 5-A to 5-D).

It should be noted that a knowledge of which hip is affected first is not enough to indicate what may happen to the contralateral hip. Of the eleven boys studied the initial involvement occurred in the right hip three times and in the left hip three times in those with marked slipping; in those with minimal slipping it occurred three times on the right and four times on the left. Although in the four girls examined the initial slipping was in the right hip, the contralateral slipping was minimal in every case, and only two required nailing *in situ*.

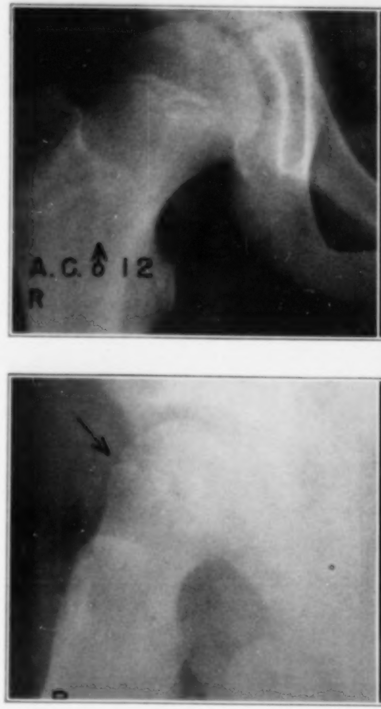

FIG. 3-A

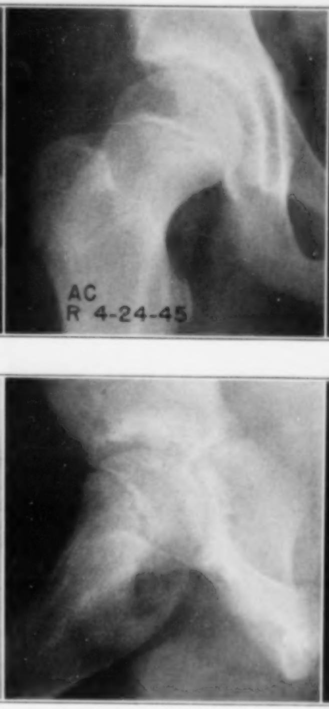

FIG. 3-B

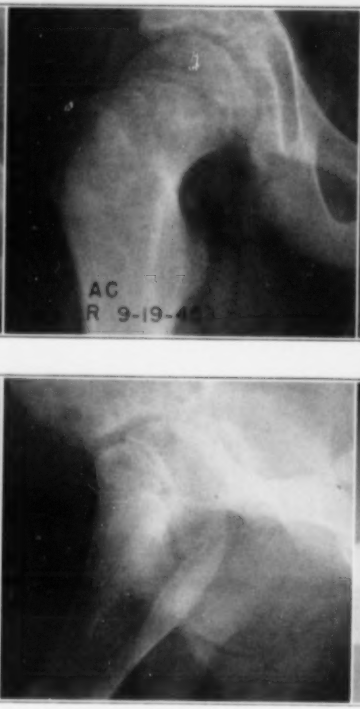

FIG. 3-C

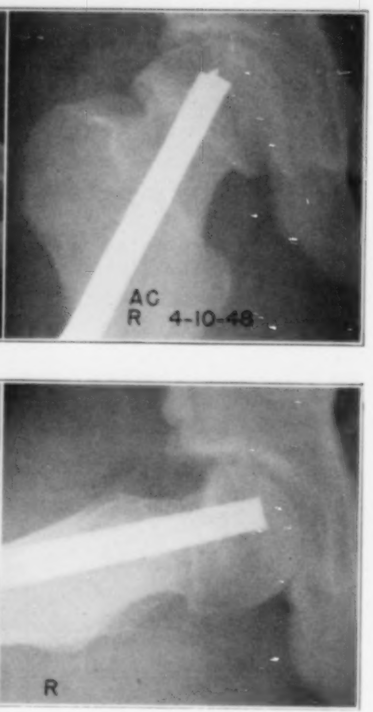

FIG. 3-D

Asymptomatic minimal slipping in the contralateral hip was made symptomatic and marked by a fall. This hip was treated by open reduction and nailing.

Fig. 3-A: A. C., boy, aged twelve on August 31, 1944. The left hip, not shown, had been nailed *in situ* for minimal slipping. In the right hip, asymptomatic minimal slipping was recognizable only in the lateral view. The arrow indicates slipping and the resulting bared angular neck.

Fig. 3-B: April 24, 1945, eight months after the left hip had been nailed, the right hip showed slight medial slipping in the anteroposterior view and posterior slipping in the lateral view. This hip was asymptomatic.

Fig. 3-C: Five months later, September 19, 1945, medial and posterior slipping was more marked. The patient was limping and his hip was painful following a fall from a haymow.

Fig. 3-D: Roentgenograms made April 10, 1948, two and one-half years after open reduction and nailing.

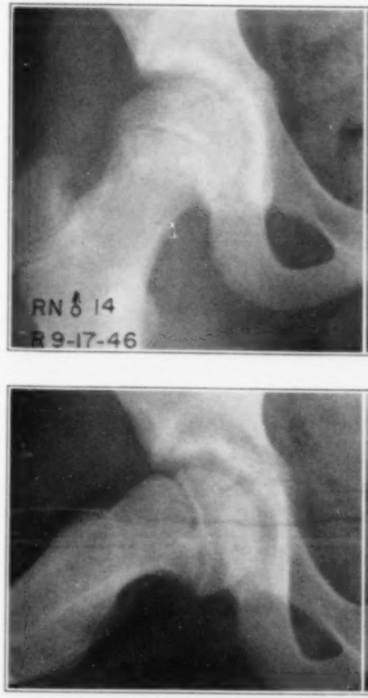

Fig. 4-A

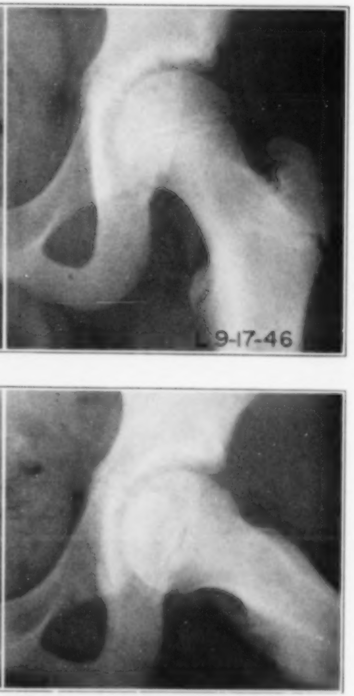

Fig. 4-B

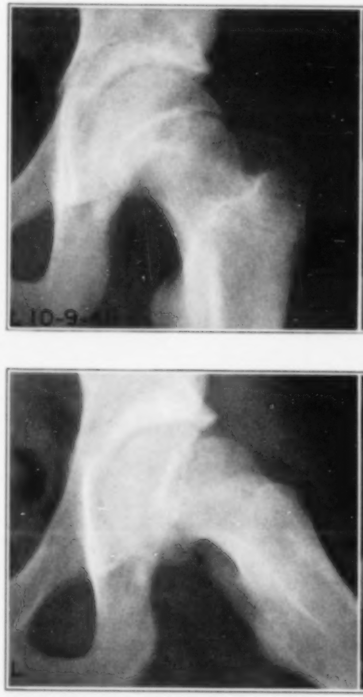

Fig. 4-C

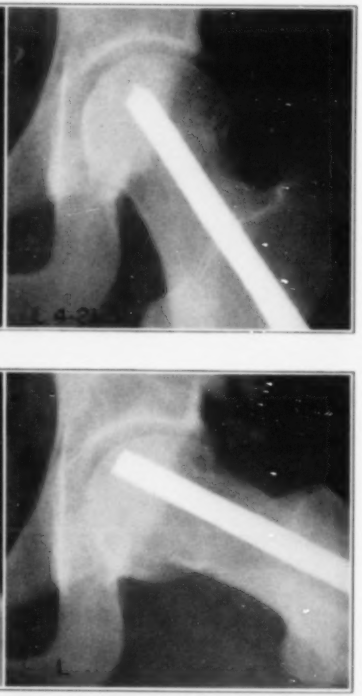

Fig. 4-D

Asymptomatic minimal contralateral slipping, which later became symptomatic and marked, was treated by open reduction and nailing.
Fig. 4-A: R. N., boy, fourteen years old. Roentgenogram made on September 17, 1946, showed minimal slipping of the right hip, which was nailed *in situ*.
Fig. 4-B: Roentgenograms of the left hip, made at the same time, showed early minimal medial slipping which was asymptomatic.
Fig. 4-C: Roentgenograms made October 9, 1948, when the patient was sixteen.
Fig. 4-D: Roentgenograms made April 21, 1951, two and one-half years after open reduction and nailing.

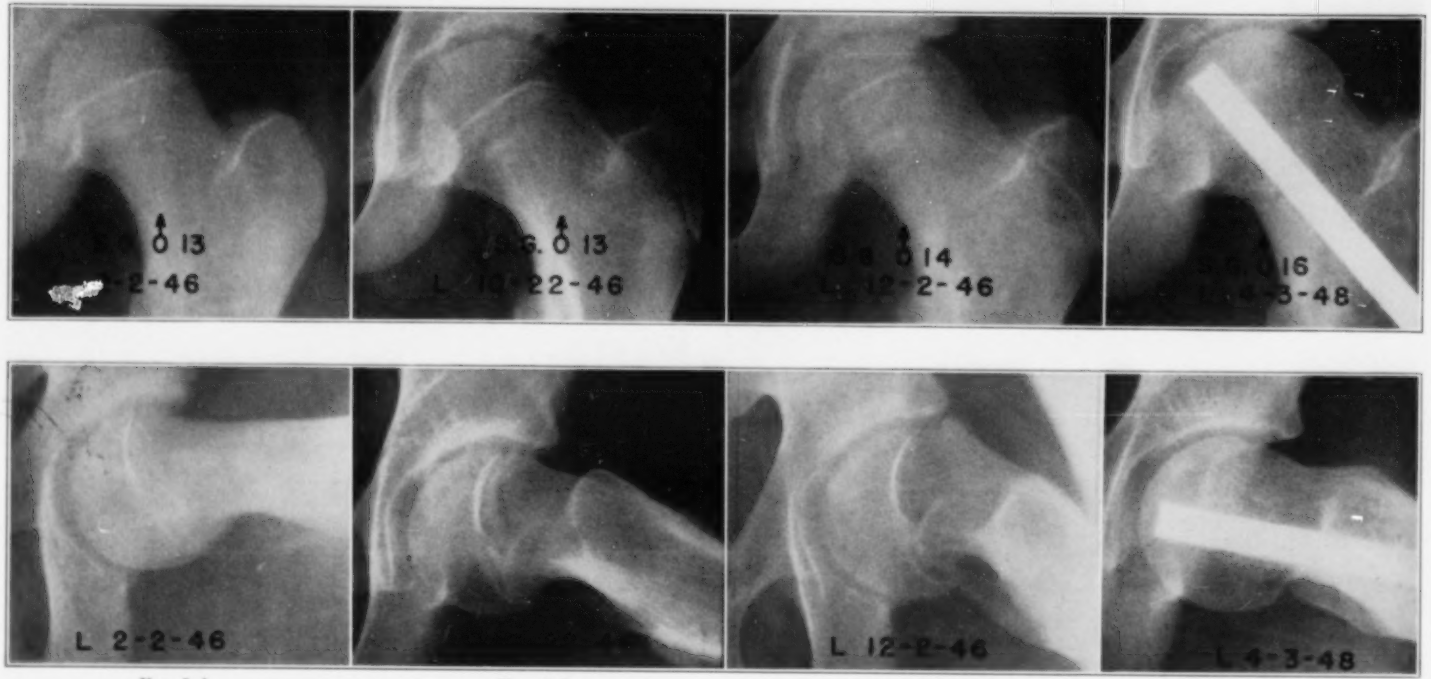

FIG. 5-A FIG. 5-B FIG. 5-C FIG. 5-D

Marked slipping in the contralateral hip, which was reduced by closed manipulation and nailed *in situ*.

Fig. 5-A: S. G., boy, thirteen years old. The right hip, not shown, was nailed after open reduction for marked slipping on February 16, 1946. The preoperative roentgenograms of the left hip shown here demonstrate minimal slipping which was not recognized. The epiphyseal line was widened. In the lateral view minimal posterior slipping was evident; the anterolateral portion of the neck was bared as it ended with an angular contour at the epiphyseal plate.

Fig. 5-B: Roentgenograms made eight months later, on October 22, 1946, showed a wider epiphyseal line, and more marked posterior slipping. Evidence of demineralization (absorption) was present at the juxta-epiphyseal portion of the neck. At this time the hip was still asymptomatic.

Fig. 5-C: Roentgenograms made two months later, December 2, 1946, showed marked posterior slipping.

Fig. 5-D: Follow-up roentgenograms, made on April 3, 1948, sixteen months after extremely gentle manipulation and nailing *in situ*.

The most constant roentgenographic indications of contralateral involvement were a widened epiphyseal plate and slipping which sometimes was of such slight extent that it could be detected only on comparison with roentgenograms of "normal" subjects of like maturation age and sex. Therefore, roentgenographic examination of the contralateral hip often enough to detect the slightest slipping is essential. Lateral as well as anteroposterior views should always be made. Both views should then be compared with those of "normal" hips to assure detection of slipping in its earliest stage.

Our experience then would seem to indicate that in an adequately controlled group only one out of eight patients in whom contralateral slipping develops will require the serious operation of open reduction and nailing. The majority of those in whom subjective symptoms appear while slipping is still minimal can be treated adequately by the simpler operation of nailing *in situ*. Approximately one third of those with contralateral slipping, however, can be expected to remain asymptomatic and go on to epiphyseal closure spontaneously with only minimal deformity. All this seems even more reassuring if these experiences are considered as applied to the entire group of sixty-one patients reviewed. When the eight who presented bilateral symptomatic slipping and were treated at their first visit are omitted from consideration, it becomes obvious that of fifty-three patients treated for unilateral slipping only two subsequently required open operation for slipping in the contralateral hip.

Therefore, if children with a slipped capital femoral epiphysis can be checked clinically every month and roentgenographically every two or three months, and, if roentgenograms of their hips can be compared with "normal" roentgenograms of children of corresponding sex and maturation age, contralateral involvement should be readily recognized even when it is asymptomatic. If patients are also warned of the danger to their contralateral hip of falls from heights or of falls suffered while they are participating in so-called "contact" sports, it should not be necessary to nail contralateral hips with slipping until they become symptomatic. If the patient, however, is not to remain under proper supervision until the contralateral epiphysis is fused, and if comparison with roentgenograms of "normal" hips shows asymptomatic slipping, nailing *in situ* to prevent further symptomatic slipping might well be considered.

1. KLEIN, ARMIN; JOPLIN, R. J.; REIDY, J. A.; and HANELIN, JOSEPH: Slipped Capital Femoral Epiphysis. Early Diagnosis and Treatment Facilitated by "Normal" Roentgenograms. J. Bone and Joint Surg., **34-A:** 233-239, Jan. 1952.

DISCUSSION

INTRAMEDULLARY FIXATION IN FRACTURES OF THE HAND AND FINGERS

(Continued from page 16)

The subcutaneous placing of the wires causes less scarring, minimizes the possibility of bone infection through the skin opening, and allows the patient to work even where his hands must be wet.

The discussor has had a patient in whom a graft was held by four subcutaneous wires in different planes and in different axes. The short, right-angled hook allows easy location and removal through an incision in the original scar. There is a large degree of motion possible in the joints proximal and distal to the fixation site.

In closing, I would like to commend Dr. vom Saal for restressing internal fixation and early mobilization and for his forceful and well documented presentation.

DR. VOM SAAL (closing): I would like to thank Dr. Littler and Dr. Metcalf for their kindness in discussing this paper.

Sometimes a method is presented which turns out to be difficult when it is tried. This method, however, is easy to follow if one will carefully observe the few simple basic principles.

ISCHAEMIC CONTRACTURE, LOCAL, IN THE HAND *

BY STERLING BUNNELL, M.D., SAN FRANCISCO, CALIFORNIA

The hand is in the normal position of function when there is proper balance between its long flexors, its long extensors, and its intrinsic muscles. If the intrinsic muscles are paralyzed, the hand assumes the "intrinsic-minus position" or that of the paralytic claw-hand. The metacarpophalangeal joints are cocked back, the distal two finger joints are clawed, the metacarpal arch is lost, and the thumb is drawn to the side and back of the hand.

If, however, the intrinsic muscles "overpull" as in spastic patients, under electric stimulation, or in fibrous contracture, the opposite, or the "intrinsic-plus position", is assumed. It is the position of a hand entering a coat sleeve. The proximal finger joints are flexed, the distal two finger joints are extended, the metacarpal arch is curved, and the straight thumb is drawn by the short adductor muscles into the palm toward the third metacarpal. What I am about to describe is a definite entity more often encountered than recognized.[1]

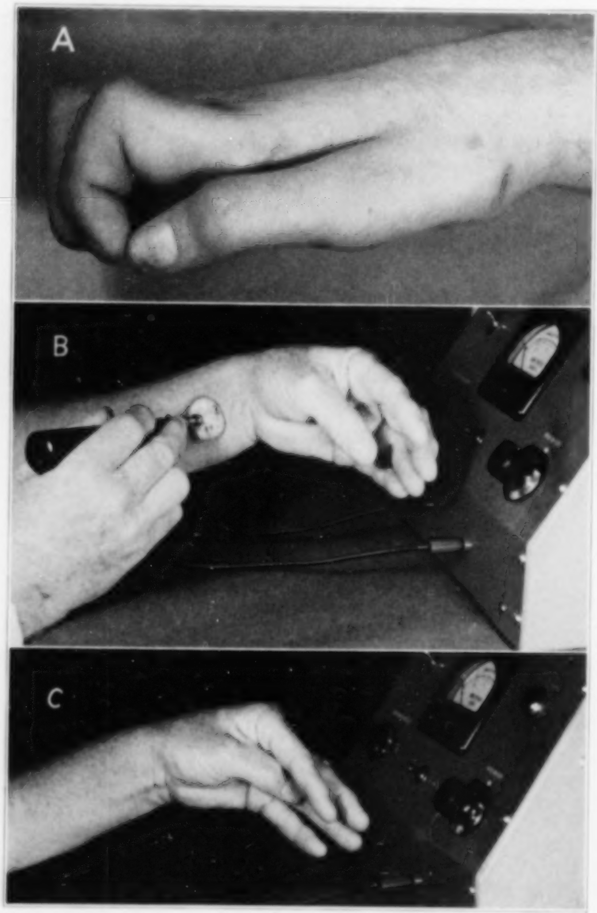

FIG. 1

A: Intrinsic-minus position from paralysis of the median and ulnar nerves.

B: Intrinsic-plus position from electrical stimulation of the median nerve.

C: Intrinsic-plus position from electrical stimulation of the ulnar nerve at the elbow.

We first realized that this entity existed in World War II, especially toward the end of the war when the dregs, or worst hands, were examined. Now that the condition is readily recognized by simple tests, it is found to be frequent even in civilian practice, and it is also encountered in the feet. I call it "ischaemic contracture, local, in the hand" in contrast to Volkmann's ischaemic contracture in the forearm.

The cause of the condition is decreased blood supply in the hand, less from a complete arterial shut-off which creates gangrene at the tips of the digits than from a local congestion or lessening of the circulation, as in the Volkmann type. The most common cause is swelling of the

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* Read at the Joint Meeting of the Orthopaedic Associations, London, July 2, 1952.

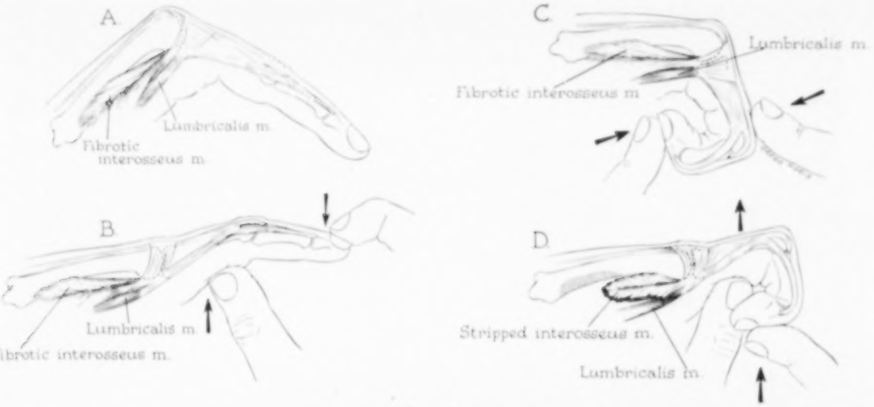

Fig. 2

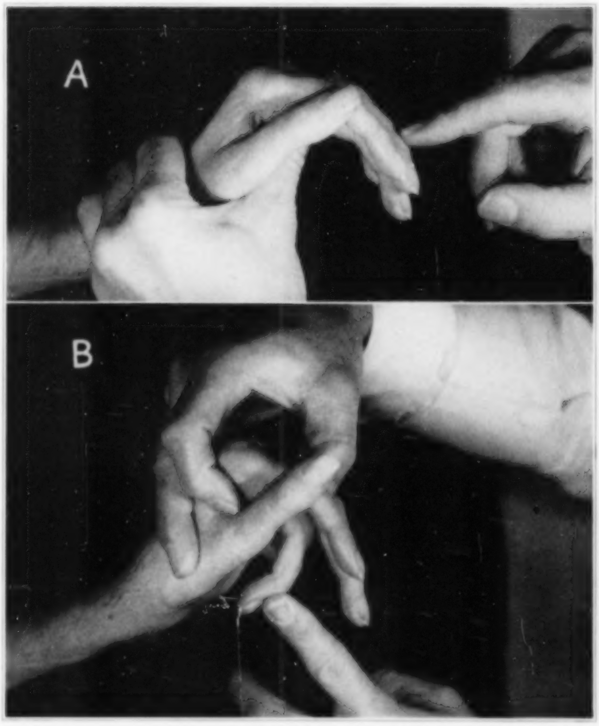

Fig. 3

Fig. 2, *A:* Intrinsic-plus position with fibrotic intrinsic muscles holding the proximal finger joint in flexion and the distal two joints in extension.

Fig. 2, *B* and *C* show the test for intrinsic contracture. When the intrinsic muscles are tensed by holding the proximal joint in extension, the distal two joints cannot be flexed; but when they are slackened by flexing the proximal joints, the distal two joints flex.

Fig. 2, *D:* When the interosseus muscle is stripped and advanced, the distal two joints flex, even when the proximal joint is held extended. (From Sterling Bunnell, E. W. Doherty, and R. M. Curtis: Ischemic Contracture, Local, in the Hand, *Plastic and Reconstructive Surgery*, **3**: 425, 1948. Reproduced by permission of The Williams and Wilkins Company, Baltimore, Maryland.)

Fig. 3: Case 1. There were open fractures of both bones of the forearm. When the cast was removed there were large pressure sores in the hand, and the distal third of the forearm and hand were numb. Recovery required two years, during which time the hand was used as a club. Volkmann's contracture was present and also ischaemic contracture, local, in the hand.

Fig. 3, *A:* Test for contracture of interosseus muscles: When examiner's thumb tightens the interosseus muscle, the examiner cannot passively flex the patient's finger in its distal two joints.

Fig. 3, *B:* Continuation of test. Examiner's thumb slackens interosseus muscle and the finger can then be flexed. When later the lateral bands were severed in this patient, the range of motion of the fingers was improved.

hand in a plaster-of-Paris encasement or even in too tight an elastic bandage. The tightness may be over the whole limb, or it may be in the hand or in only a part of it. Just as in Volkmann's ischaemic contracture, where often there are telltale signs of pressure such as scars from necrosis in the antecubital space and sides of the wrist, so in this entity

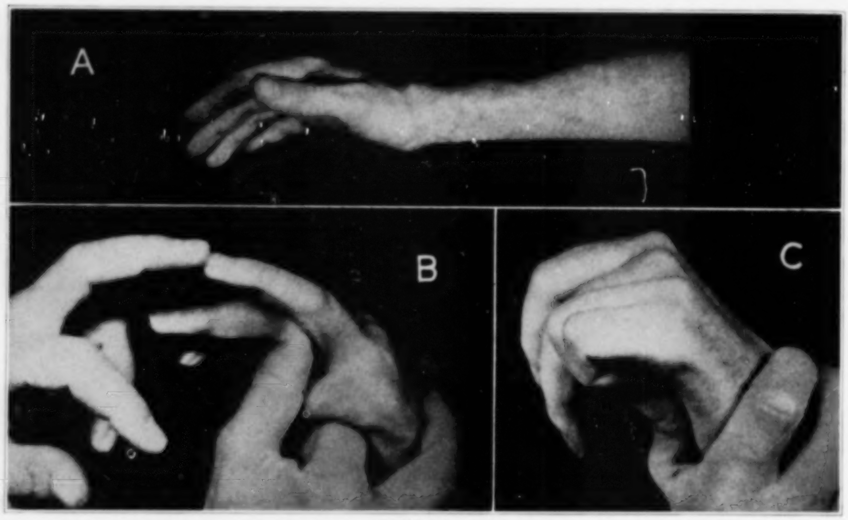

Fig. 4

Case 2

A: Ischaemic contracture of interossei and contents of thumb cleft, which followed fracture of both bones of the forearm. There was tightness of the plaster cast.

B and *C:* Test for interosseus contracture. In *B* the interosseus muscle is made taut and the distal two joints cannot be flexed. In *C* the interosseus muscle is loose and finger joints will flex. (From Sterling Bunnell, E. W. Doherty, and R. M. Curtis: Ischemic Contracture, Local, in the Hand, *Plastic and Reconstructive Surgery*, **3**: 426, 1948. Reproduced by permission of The Williams and Wilkins Company, Baltimore, Maryland.)

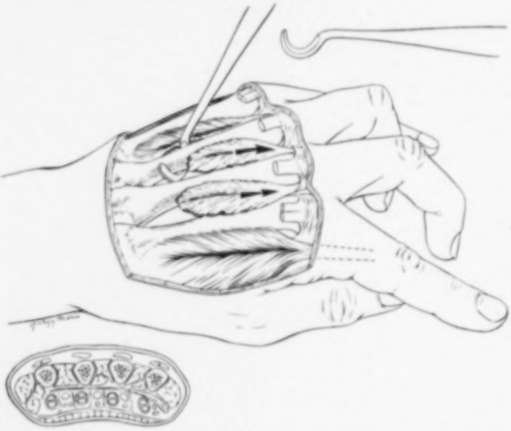

Fig. 5

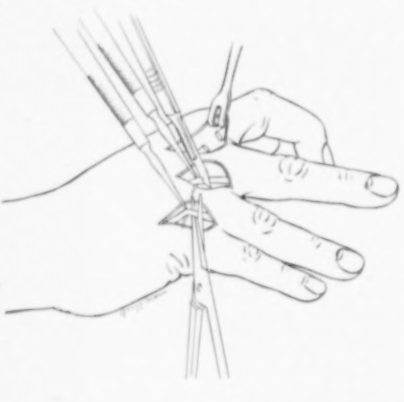

Fig. 6

Fig. 5: Method cf stripping and advancing interosseus muscles in order to slacken them, thus allowing the proximal finger joints to extend and the distal two to flex. The interosseus muscles of two of the clefts have been stripped. The insert shows a cross section through the middle of the hand.

Stripping of the interossei is done only when these muscles still retain considerable function. The nerve supply should be spared.

Fig. 6: Method for tenotomy of the lateral bands. This is done for severe interosseus contracture when very little function of the interosseus muscle remains. After operation the hand is immobilized in the claw position.

such scars are commonly found about the hypothenar eminence, the thenar eminence, or the radial border of the hand.

The contracture also may follow gross damage to the great vessels and nerves well up the arm, as is seen in the Volkmann type, and it may accompany Volkmann's ischaemic contracture, or it may occur entirely independent of it. In most cases both the fingers and the thumb cleft are involved, but in some the involvement in either may be paramount. In a few the contracture is more local from direct injury confined to part of the thenar eminence or in a lumbrical or interosseus muscle.

Signs

This entity is recognizable by the characteristic posture of the hand with the proximal finger joints in flexion, the distal two joints in extension, and the straight thumb in the palm. The diagnosis may be verified by the following test: For contracture of the interosseus or lumbrical muscles, these are first made taut by passively forcing the metacarpophalangeal joints into extension. Tapping on the finger nail will then meet with such resistance that the distal two finger joints

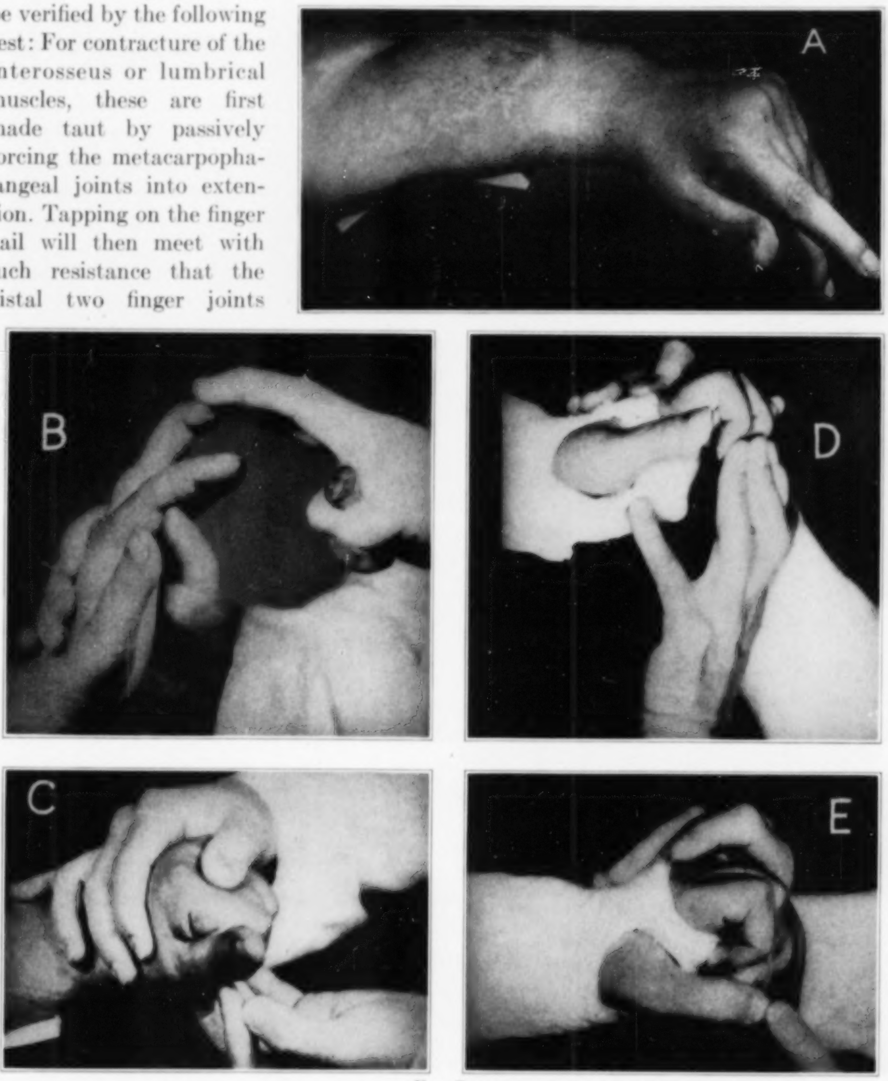

Fig. 7

Case 3

A: Ischaemic contracture, local, in the hand. Showing typical position due to effects of impaired circulation from mortar-shell wounds in the forearm.

B and *C:* Test showing contracture of intrinsic muscles to fingers.

D: Showing correction after the stripping operation on the interosseus muscles.

E: Width of thumb cleft has been increased by stripping of adductors of thumb. (From Sterling Bunnell, E. W. Doherty, and R. M. Curtis: Ischemic Contracture, Local, in the Hand, *Plastic and Reconstructive Surgery*, **3:** 431, 1948. Reproduced by permission of The Williams and Wilkins Company, Baltimore, Maryland.)

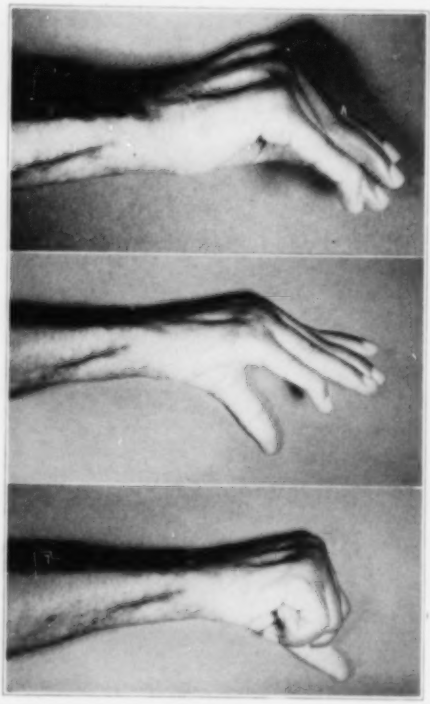

Fig. 8

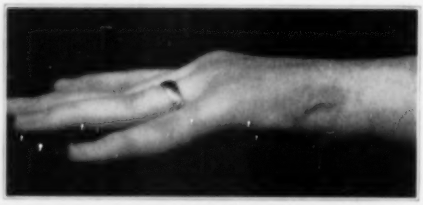

Fig. 11

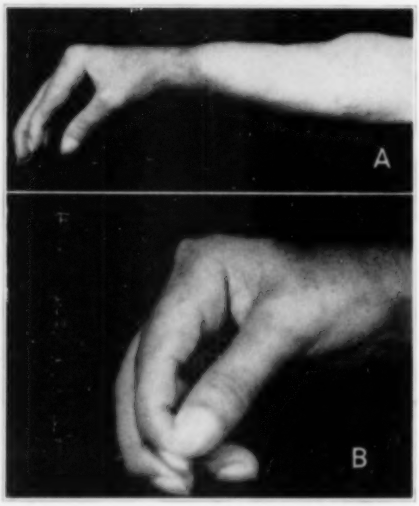

Fig. 12

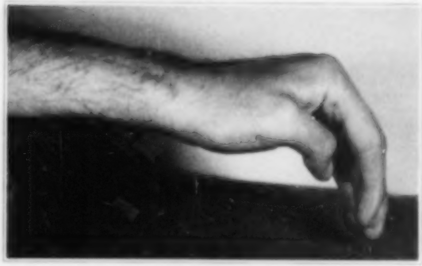

Fig. 9

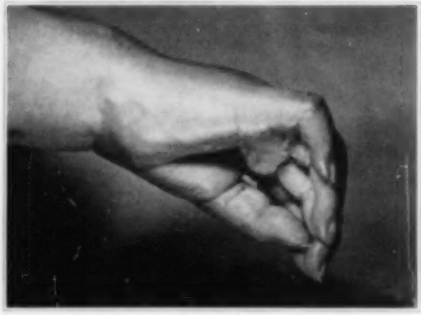

Fig. 10

Fig. 8: Case 4. A crush of the arm and elbow and a burst forearm were followed by encasement in a plaster cast for two months. The result was marked interosseus and thumb-web contracture.

Tenotomies on the lateral bands and severance of some collateral ligaments, together with tendon transfers for opposition and abduction of the thumb, resulted in great improvement in the metacarpophalangeal joints. These eventually lacked only 40 degrees of full extension.

Fig. 9: Case 5. For a fracture of the humerus and of the radial styloid, traction and a plaster cast were applied for five days, followed by a hanging cast for a month and a half. On removal there was at first no motion or sensation in the fingers. Both interosseus contracture and thumb-cleft contraction were present, as well as some Volkmann's ischaemic contracture in the forearm. The hand was improved by a zig-zag plastic operation on the thumb cleft and stripping of the thenar muscles from the third metacarpal.

Fig. 10: Case 6. A severe crush of the forearm and metacarpals followed by a pressure dressing resulted in contracture of the interosseus and thenar muscles seen here. There was poor opening of the hand for grasp.

Fig. 11: Case 7. After an open reduction of the humerus and skeletal traction, and application of a cast for a few days, the patient could not extend his fingers. The photograph shows the contracture of the intrinsic muscles and the scar from a pressure sore in the ulnar border of the hand. Another such scar is on the radial border. In this case there was some spontaneous improvement.

Fig. 12: Case 8. The runners of a crane passed over this patient's hand, fracturing the bones of the

(*Continued on page 93*)

(Fig. 12: Continued)

carpus. Contracture of the intrinsic muscles developed in the thumb and fingers. The metacarpals were realigned with the carpus. *A* and *B* show the effects of intrinsic contracture. *A* shows limit of extension of the fingers and *B* shows the limit of flexion.

Later the thumb cleft was opened; a pedicle was applied; and the lateral bands in the fingers were severed. The improvement consisted of excellent function, a wide cleft, improved extension in the metacarpophalangeal joints, and flexion in the distal two.

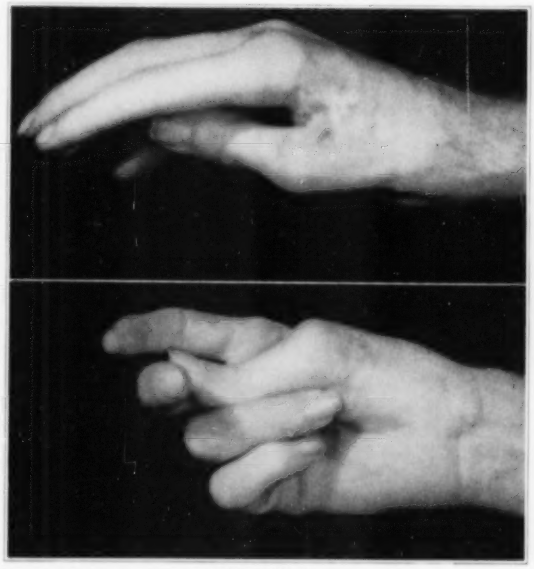

FIG. 13-A

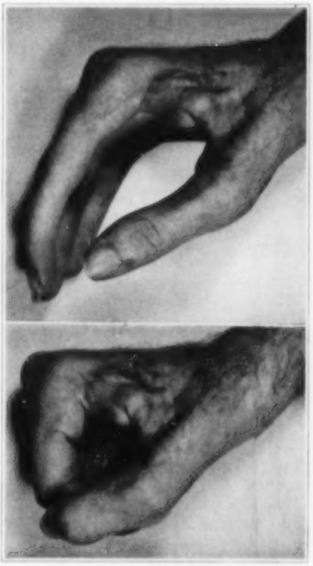

FIG. 13-B

Case 9. The hand was crushed and a cast was applied.

Fig. 13-A: The photograph shows scars from pressure sores and the position in contracture of the intrinsic muscles both of the interossei and of the thumb cleft. The contracted muscles of the thumb cleft were excised; the index finger was "filleted" and transferred on a neurovascular pedicle to cover the thumb cleft. Fig. 13-B: Showing the postoperative result.

cannot be flexed, while they readily flex if the metacarpophalangeal joints are held in flexion. Ischaemic contracture in the foot is shown by a similar test.

If there is contracture of the thenar muscles, the thenar eminence feels indurated, and an attempt to widen the angle between the first and third metacarpals meets with rigid resistance as the short adductors of the thumb and secondarily all other tissues have contracted.

Symptoms

The main complaint is that the hand cannot be opened for grasping. The thumb is in the way and cannot be extended from its position in the hand, and the metacarpophalangeal joints cannot open from their flexed position. There may also be complaints of weakness, numbness, anaesthesia, induration, and signs of poor nutrition of tissues.

TREATMENT

Prophylactically great care should be used to avoid swelling of the hand or arm in tight encasements. When a hand is in a tight cast, the blood supply is squeezed out and all intrinsic muscles are rendered ischaemic and then contract. If the hand is clumped, the short adductor muscles of the thumb suffer most. When the condition is discovered, relief should be undertaken immediately.

Later, in surgical correction, our aim is to loosen the lateral bands in the fingers and to open out the thumb cleft. Voluntary action cannot be expected to be restored to fibrotically contracted muscles.

TABLE I

SUMMARY OF TWENTY-FIVE CASES OF ISCHAEMIC CONTRACTURE, LOCAL, IN THE HAND

Case No.	Cause of Contracture	Symptoms and Disability	Operative Procedures	Result
1.	Fell in mountains on arm. Forearm bones fractured. After treatment by cast, numbness in hand and forearm, large pressure sore.	Thumb touched only ring and little fingers. Volkmann's ischaemic contracture, interosseus contracture, and thumb-cleft contracture present.	Bones of hand realigned and wrist arthrodesed. Thumb cleft opened and abdominal pedicle applied. Tenotomy of lateral bands.	Thumb in excellent position with wide cleft, lacks 2 inches of extension. Ring and little fingers lack 2½ inches of extension. Useful hand.
2.	Fractured forearm bones immobilized in cast.	Interosseus contracture.** Thumb-cleft contracture.* Also Volkmann's contracture.		
3.	Shell wound in forearm.	Interosseus contracture.** Thumb-cleft contracture.**	Interossei and muscles of thumb cleft stripped.	Good.
4.	Crush of upper arm and elbow. Forearm burst, humerus fractured, cast for two months.	Interosseus contracture.** Thumb-cleft contracture.* Some Volkmann's contracture.	Tenotomies of lateral bands of three fingers. Two collateral ligaments severed. Tendon transfer for opposition and abduction.	Thumb has good position and movement. Fingers greatly improved. Metacarpophalangeal joints lack 40 degrees of extension.
5.	Fractured humerus and radial styloid treated by traction and plaster for 5 days and hanging cast for 1½ months.	On removal of cast fingers were numb and there was no motion for 3 months. Interosseus contracture.** Thumb-cleft contracture.** Also Volkmann's contracture.	Opened thumb cleft, zig-zagging skin, and stripping muscles.	Improved.
6.	Severely crushed and fractured forearm and metacarpals treated by pressure dressing.	Interosseus contracture.*** Thumb-cleft contracture.*** Opened between thumb and fingers for grasp 2¼ inches.	Nutrition too poor for operation.	Fair.

(Table I—*Continued*)

7. Crush of humerus and elbow, open. Skeletal traction for 10 weeks, cast for a few days. Patient then could not extend three fingers.	Interosseus contracture.** Scar of radial border and over hypothenar eminence. Metacarpophalangeal joints lack 20 to 30 degrees of extension. Thumb in good condition.	No operation done, but some improvement.	Good.
8. Hand crushed under runners of crane.	Thumb drawn by scar to side of hand. Touches ring and little fingers.	Bones of hand realigned. Thumb cleft formed; abdominal pedicle applied to cleft.	Thumb in excellent position with wide cleft, lacks 2 inches of extension. Ring and little fingers lack 2½ inches of extension at tips. Useful hand.
9. Crushed hand, with pressure sores from subsequent cast treatment.	Thumb-cleft contracture.*** Thumb touches last two fingers. Interosseus contracture.*	Thumb-cleft muscles excised and thumb cleft covered by "filleted" index finger on a neurovascular pedicle.	Improvement in spread of thumb.
10. Belt-and-pulley injury. Multiple forearm fracture, treated by cast for 3 months.	Ischaemic contracture in hand, Volkmann's contracture in forearm. Interosseus contracture.*** Thumb-cleft contracture.*** Inability to hold anything, anaesthesia.	Tenotomies of lateral bands. Thumb-cleft muscles excised, joint incised. Bone block for cleft and skin graft.	Fairly good.
11. Arm hung by wrist for two days after operation.	Interosseus contracture.** Thumb-cleft contracture.**	Marginal interossei stripped. Tenotomies of lateral bands of two central fingers. Muscles of thumb cleft excised, capsule cut. Crossed Kirschner wires and abdominal pedicle graft.	Good; patient grasped well.
12. At age eleven fracture of radius and ulna from fall, treated by cast for six weeks. Sores on thenar and hypothenar eminences slow to heal.	Thumb is in the way, tight in palm. Fingers extend, but hypothenar scar holds little. Metacarpophalangeal joint of thumb drops on pinch from scar which draws first two metacarpals together.	Contents of thumb cleft excised. Adductors stripped from third metacarpal. Trapeziometacarpal joint cut all around. Origins of opponens and flexor muscles detached and carpal ligament cut across. Pedicle graft and skin graft for hypothenar eminence.	Fingers normal. Thumb lacks 1 inch of extension, 1¼ inches of flexion and adduction. Opposes to 2 inches in front of index finger with nail at 40-degree angle.

(*Continued on page 96*)

(Table I—*Continued*)

Case No.	Cause	Symptoms and Disability	Operative Procedures	Result
13.	Tight cast with hand clumped because of fractured humerus.	Worst in thumb cleft and first two fingers. Interosseus contracture.* Thumb-cleft contracture.**	Interossei and muscles of thumb cleft stripped.	Good.
14.	Hand crushed between metal. Fractured three metacarpals. Infection.	Thumb at side, cannot spread from index, no opposition. Interosseus contracture.** Thumb-cleft contracture.**	Muscles excised from thumb cleft. Wedge osteotomy of thumb metacarpal. Crossed Kirschner wires and abdominal pedicle. Tenotomies of lateral bands.	Good.
15.	Elastic pressure dressing after skin-grafting for burns for twelve days.	Extreme deformity, interosseus and thumb-cleft contracture.*** Hyperextension of middle-finger joints.	Tenotomies of lateral bands. Arthrodeses of several finger joints. Excision of thumb cleft and skin grafts.	Good.
16.	Shell wounds of shoulder, arm, and wrist, with impaired circulation.	Interosseus contracture.** Thumb-cleft contracture.**	Interossei stripped. Thumb cleft opened.	Fairly good.
17.	Elastic-bandage pressure dressing for burn.	Interosseus contracture of long and ring fingers.**	Tenotomies of lateral bands. Severed also collateral ligament, radial side, and volar capsule.	Much improvement in position and function.
18.	Shotgun injury through upper arm. Vessel block. Fascia of forearm split.	Interosseus contracture.** Thumb-cleft contracture.** Inability to open hand more than 1¼ inches.		
19.	Both bones of forearm fractured and treated by cast.	Thumb-cleft contracture.*** Interosseus contracture.**		
20.	Lacerated wrist treated by cast for six weeks. Wrist manipulated under pentothal anaesthesia.	Thumb cleft obliterated, median nerve injured.	Thumb cleft opened. All fibrous muscle excised and joint capsule incised. Kirschner wires applied. Pedicle graft.	

(Table I—*Continued*)

21. Belt-and-pulley crushed hand. Infection.	Thumb-cleft contracture.*** Volkmann's contracture.***	Thumb cleft opened by excision of muscle and cutting of joint capsule. Closed by "fillet" from injured ring and long fingers.	Poor, but better than prosthesis. Patient can grasp light objects.
22. At age twelve hand and forearm injured between rollers.	Thumb-cleft contracture.*** Interosseus contracture. Ring and little fingers awkward. Scar thumb web spread from index finger ½ inch.	Fibrous muscles excised from thumb web. Crossed Kirschner wires, abdominal pedicle applied. Tenotomies of lateral bands, ring and little fingers.	Improved.
23. Gunshot wound of forearm. Severe burn; pressure dressings applied.	Interosseus contracture.*** Thumb-cleft contracture.***	Stripped all interossei, but had to perform tenotomies of lateral bands of long and ring fingers; excised all fibrous muscle from thumb cleft. Incised capsule. Abdominal pedicle and ilium-graft block in cleft.	Thumb has satisfactory range of motion. Useful hand. Patient found fit for duty in navy.
24. Injured in cave-in. Open fractures of radius and ulna treated by cast.	Interosseus contracture.* Thumb-cleft contracture.* Weak, numb, atrophy of intrinsic muscles.	Cicatrix excised from thumb cleft. Crossed Kirschner wires. Extensor profundus transferred to lateral band of index finger.	Good.
25. Plaster cast applied after gunshot wound.	Little finger gangrenous. Interosseus contracture.*** Thumb-cleft contracture.*** Pedicle had been applied to palm erroneously!	Bones of hand realigned. Thumb cleft formed. Abdominal pedicle to cleft.	Thumb in excellent position. Wide cleft. Lacks 2 inches of extension. Ring and little fingers lack 2½ inches of extension at tips. Useful hand.

The asterisks indicate the degree of contracture: mild (*), moderate (**), severe (***).

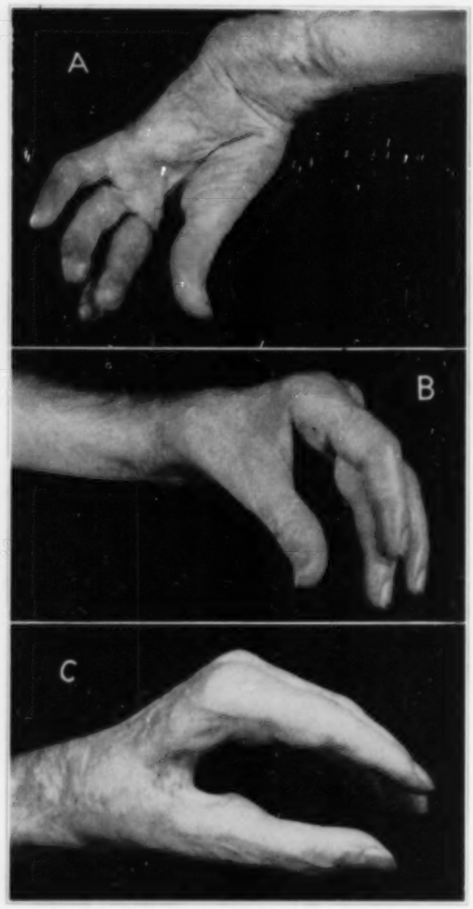

Fig. 14

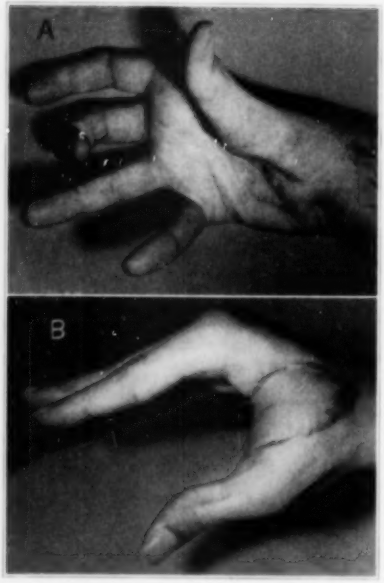

Fig. 15

Fig. 14: Case 10. This patient sustained a belt-and-pulley injury with multiple fractures. A cast was applied for three months. Severe ischaemic contracture, of both the Volkmann type and the local type in the hand, resulted. All intrinsic muscles of the hand were involved and the patient had no power to hold anything.

The contents of the thumb cleft were excised. The cleft was held open by a bone-graft block and a split-skin graft was applied to it. Tenotomies were done to all the lateral bands.

Fig. 14, *A* and *B* show the condition before operation; *C* shows the postoperative condition. The patient obtained a fairly useful hand.

Fig. 15: Case 11. *A* shows ischaemic contracture of the interossei and the thenar muscles, which was caused by suspending the arm by the wrist for two days in order to elevate it after an operation.

Fig. 15, *B* shows improvement of the hand after some interossei had been stripped and others tenotomized; the fibrous muscles in the thumb cleft had been excised and a pedicle graft had been applied.

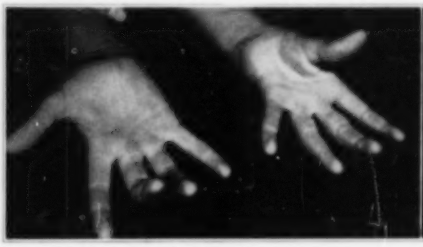

Fig. 16-A

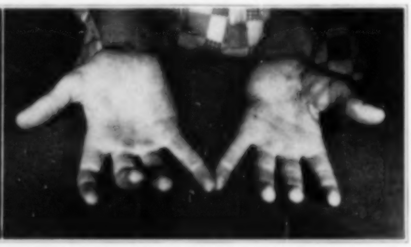

Fig. 16-B

Fig. 16-A: Case 12, aged eleven. As a result of a fall both bones of the forearm were fractured. When the cast was removed after six weeks, pressure sores were found over the hypothenar and thenar eminences; these were long in healing. Contracture of thumb cleft is evident, but the interossei were spared. The thumb lacked, as measured at its tip, one and one-half inches of full extension and one and one-half inches of reaching backward to the plane of the dorsum of the hand.

Fig. 16-B: Most of the contents of the thumb cleft were excised. It was necessary to sever the capsule of the trapeziometacarpal joint entirely, as well as to sever the origin of the opponens muscle and to cut across the volar carpal ligament of the wrist. A pedicle graft was applied to the thumb cleft and a split graft to the hypothenar eminence. There was a fairly good result.

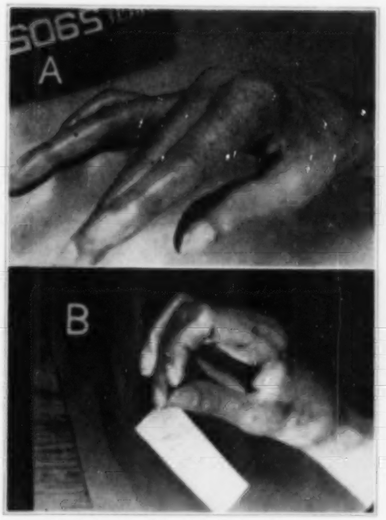

Fig. 17

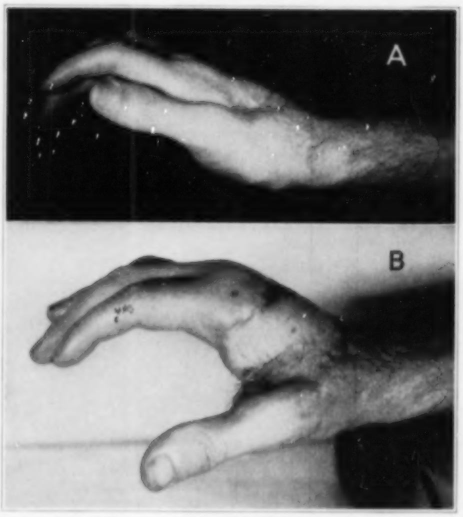

Fig. 18

Fig. 17, *A:* Case 13. Ischaemic contracture, local, in the hand, resulting from a tight cast which had been applied for a fracture of the humerus and had enclosed the fingers in a clumped position.

Fig. 17, *B:* The interossei were stripped and advanced, and the adductors of the thumb were disconnected from the third metacarpal. Postoperative fixation was in the claw position. The result is shown. (Courtesy of Donald R. Pratt.) (From Sterling Bunnell, E. W. Doherty, and R. M. Curtis: Ischemic Contracture, Local, in the Hand. *Plastic and Reconstructive Surgery*, **3**: 429, 1948. Reproduced by permission of The Williams and Wilkins Company, Baltimore, Maryland.)

Fig. 18, *A:* Case 14. Following a direct crush to the hand and infection, contracture developed in the thumb cleft and in the interossei muscles.

Fig. 18, *B:* The muscles were excised from the thumb cleft and the position of the thumb was corrected by a wedge osteotomy. A pedicle graft was applied. The extensor proprius tendon was transferred to the lateral band of the index finger. The result is shown in the photograph.

Fingers

For the fingers one should decide whether merely to advance the interosseus muscles, their function being retained as in a Steindler stripping operation in the foot, or to discard them and tenotomize the lateral bands. Their nerve supply which enters the volar aspect should be preserved.

The examiner can demonstrate function by feeling the lateral bands in action at the sides of the fingers, by noting ability to spread the fingers and pinch between them, as well as the ability to extend the distal two finger joints. If function is present, a stripping or advancement operation is indicated, but if not, tenotomy of the lateral bands must be done.

In mild cases with good interosseus function, the elastic reverse knuckle-bender splint may extend the metacarpophalangeal joints and there may be some tendency to recover.

With a small curved periosteal elevator inserted through the dorsum, the interossei are separated from the metacarpals and allowed to advance distally until the proximal finger joints will extend and the distal two will flex.

If the intrinsic muscles are too fibrous to functionate or if a trial at stripping is not successful because of an excess of adhesions about the metacarpal head, tenotomies of the lateral bands should be done through a short longitudinal incision in the dorsal aspect of each of the three finger webs, until the fingers can be fully flexed when their metacarpophalangeal joints are extended. It may be necessary also to sever collateral or volar ligaments.

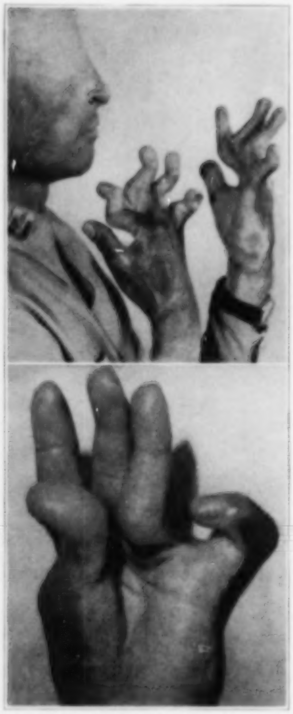

FIG. 19-A

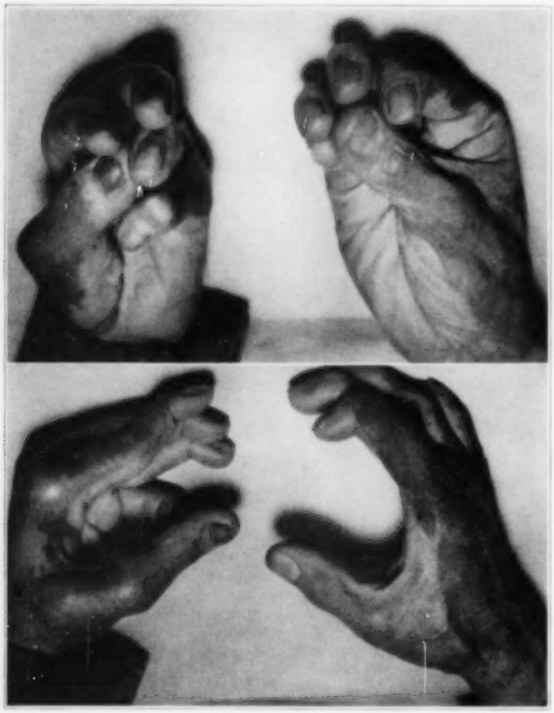

FIG. 19-B

Fig. 19-A: Case 15. Four years previously the hands and face of this patient had been severely burned in an airplane crash. Several skin-grafting procedures had been done on the hands. Following one of these, one year before this picture was taken, the elastic bandages of the compression dressings had been left on for twelve days. When these were removed, the hands showed discoloration and necrosis in the thenar eminences.

After three months severe deformities from contracture of the intrinsic muscles developed. At that time the patient was not even able to hold a piece of paper.

Fig. 19-B: These photographs show the postoperative results. Tenotomies had been done on the lateral bands, and the fibrous musculature of the thumb clefts had been excised. It had been necessary also to sever the collateral ligaments and the volar capsule in some of the fingers and the capsule of the carpometacarpal joint of the thumbs, both in front and in back. Web contractures had been attended to and several of the middle and distal finger joints were arthrodesed in the position of function. The result in appearance and function was very good, considering the extreme degree of crippling.

Thumb

Skeletal traction for spreading of the thumb succeeds in only the mildest cases. Surgical repair is done by cutting across the thumb cleft from hinge to hinge,—that is, from the juncture of the first two metacarpals in the front to that in back. Then the fascia of the cleft is excised, and the various contracted muscles are stripped from the bones, and are tenotomized or excised according to their degree of fibrosis. The first interosseus muscle may be stripped from both metacarpals and the origin of the adductors of the thumb may be scraped from the third metacarpal. All degrees of fibrous, degenerated contracted muscle may be found. The pathological changes are the same as in the muscles found in Volkmann's ischaemic contracture. Often the whole solid fibrous mass must be excised; even so the first two metacarpals may not spread until the joint capsule is cut across. Here the deep branch of the radial artery should be seen and protected.

The spread of the thumb cleft must be maintained, either by the temporary insertion of two Kirschner wires crossing through the first two metacarpals or by a bone block pinned between them. New skin must be placed as a long, diamond-shaped graft across the cleft from hinge to hinge, either by a free graft which is poor and unsightly or by an abdominal pedicle graft which furnishes fat to fill the space. This is usually done in one stage as a tube pedicle procedure. A tendon transfer for opposition of the thumb may be necessary.

Contracture of the intrinsic muscles in the hand is frequently observed in rheumatic hands with grotesque deformity. Here it is not the result of ischaemia, but is the end result of the inflammatory process affecting both joints and soft parts.

RESULTS

In such a severe condition results cannot be excellent, as there is too much induration, fibrous contracture, tissue damage, and poor nutrition. However, a hand may be placed into a much better position for function and made so that it can open for grasping; thus the main disability of this condition may be overcome.

Table I presents a summary of twenty-five typical cases of ischaemic contracture, local, in the hand. Many more cases were seen. The first fifteen cases in the summary are illustrated. The asterisks in the summary indicate the degree of contracture.

1. Bunnell, Sterling; Doherty, E. W.; and Curtis, R. M.: Ischemic Contracture, Local, in the Hand. Plast. and Reconstruct. Surg., **3**: 424–433, 1948.

DISCUSSION

Dr. Leo Mayer, New York, N. Y.: It was in January 1918, thirty-four years ago, that Dr. Bunnell published his first paper on surgery of the hand. It appeared in *Surgery, Gynecology, and Obstetrics* and was entitled Repair of Tendons in the Fingers and Description of Two New Instruments (Vol. **26**, pp. 103–110). A few weeks later we met and spent one entire day dissecting, discussing, and operating. That day I will never forget. The friendship begun there has ripened with the years; the originality and skill which then betokened a surgeon of most unusual potentialities have, as they matured, made Bunnell the accepted master surgeon of the hand. He has contributed scores of articles which have helped to create a new branch of surgery, and his book is regarded as the bible of hand surgeons.

His paper today, like all the others, is original and most instructive. Until 1948, when Dr. Bunnell first called attention to this entity at the meeting of the American Society for Surgery of the Hand, no one had recognized the existence of local ischaemic contractures of the hand. Hand surgeons are accustomed to the terms "intrinsic-minus" and "intrinsic-plus" positions, referring to the positions assumed during paralysis or overaction of the intrinsic muscles. We are all familiar with the claw-hand, or *main en griffe*, resulting from paralysis of the interossei and lumbricales. We are less familiar with the opposite condition, resulting from the fibrous contracture of these same muscles. The proximal phalanges of the fingers are held flexed and the terminal phalanges are extended; the thumb is drawn into the palm by the contracted adductors. Function of the hand is markedly reduced. The condition, as Dr. Bunnell has said, "is more often encountered than recognized". We did not realize that the same pathological processes which characterize Volkmann's ischaemic contractures were responsible for this intrinsic-plus position, the only difference being the muscles involved. Dr. Bunnell's studies, conducted during the final months of World War II, gave us the explanation, the tests for accurate recognition, and the best means of treatment.

His paper and his illustrations speak for themselves. As discussor, I want to stress the following: first, the prophylaxis. Since the most common cause of "ischaemic contracture, local, in the hand" is excessive pressure caused by swelling of the hand within a constricting plaster or elastic bandage, we as orthopaedic surgeons must not only avoid this danger ourselves, but must constantly remind our students and other members of the profession of the risks inherent in any type of circular constriction applied to the forearm and hand. The lower extremity also is not immune. Who of us has not been guilty of this physiological sin? I well remember one case where, owing to a brisk postoperative hemorrhage following an extensive hand operation, I applied an elastic compression bandage, and was not recalled to my senses until a few hours later when the patient complained of severe pain. Fortunately no permanent damage had been done, but how close I came to causing local ischaemia!

The second point to be stressed is the possibility of improving the function of this type of crippled hand by appropriate operation. If some power is still present in the interossei, they can be stripped from the metacarpals and advanced as has been done in the operation for Volkmann's ischaemia of the flexor muscles of the forearm. If, however, the muscles are too fibrous, the contracture must be corrected by division of the lateral bands consisting of the tendons of the interossei and lumbricales. The adduction of the thumb must be freed by division of the tight structures, excision of fibrous muscles, and adequate fixation of the first and second metacarpals by crossed Kirschner wires or bone block. Adequate skin coverage can best be secured by an abdominal pedicle flap.

Perfect restoration of function cannot be expected, but improvement can be secured.

THE ETIOLOGY OF SEPARATE NEURAL ARCH *

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The work that established the location of the fundamental lesion of spondylolisthesis was reported by Robert of Coblenz in 1855, one year following Kilian's classical description of spondylolisthesis. Robert demonstrated forward dislocation of the body of the last lumbar vertebra after its neural arch had been cut through and a force equivalent to its usual weight-bearing load had been applied. He reported further that, if all the ligaments connecting the last lumbar vertebra to the sacrum are cut, no displacement occurs providing the neural arch is intact.

Four years later it was announced by Schwegel that he had found in several foetus two centers of ossification in each side of the neural arch. Failure of fusion of these centers, he concluded, explains the origin of neural-arch separations. He gave no details of the study, stating only that the two centers fuse very early in most instances and, therefore, are rarely found before union has taken place.

It was in 1864 that Rambaud and Renault published their controversial treatise on the origin and development of bones. These authors stated that most anatomists (Albinus, Béclard, Coiter, Fallopio, Kerkring, Riolan, and Spiegel) had found three primary centers of ossification for a vertebra, one in the body and one in each side of the neural arch. However, Rambaud and Renault went on to state that actually each side of the neural arch is ossified from two centers, one for the superior articular process and pedicle and one for the inferior articular process, lamina, and half of the spinous process. These findings were derived partly through the study of "transparencies", and partly through dissection of the ossification centers out of their cartilaginous matrix; the number of specimens studied and the method of preparing the transparencies were not given. These centers were assembled in the position they had occupied in the foetal vertebra and drawings of the reconstructed vertebra were presented. The line separating the two ossification centers described for each side of the neural arch is in exactly the same position as that separating the two portions of the vertebra in a case of separate neural arch. The method that these writers used might well make it appear as though two centers were present, particularly in young specimens, since the isthmus consists of a very narrow neck of bone[31,70] which might easily have been fractured during the dissection or overlooked in the "transparencies". The conclusion of Rambaud and Renault was accepted by many investigators as a proper explanation for the genesis of the separate neural arch.

Without citing support for his statements, Farabeuf in 1885 described the same pattern of ossification to the *Société de Chirurgie de Paris*. Poirier and Charpy in 1911 accepted this thesis also, but were reluctant to believe that separation of the neural arch was the result of failure of such centers to fuse. They reasoned that failure of fusion in the arch would be accompanied by a separation between the body and the pedicle. LeDouble, however, was less willing to accept the conclusions of Rambaud and Renault, since his own investigation disclosed no more than three primary centers, the number described by the earlier anatomists. In spite of this, he reproduced Farabeuf's diagram of the ossification of a vertebra, in which two centers for each side of the neural arch are shown, and stated that Rambaud and Renault had shown it to be the common manner of development. He repeated the same objections to the theory of congenital origin of

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* Received for publication November 19, 1951.

the separate neural arch which had been expressed by Poirier and Charpy the year before. Bardeen[3] did not give the basis for his statement that sometimes in the fifth lumbar vertebra and occasionally in some of the others there could be found two centers for each half of the neural arch. This statement was made five years after his study of Mall's collection of embryos[2]; in the earlier article he had not described this pattern of ossification. The monograph of Dieulafé and Dieulafé, published in 1930, also states that the normal pattern of ossification consists of two centers in each half of the neural arch, but support for this statement is not provided.[19] The diagrams presented appear to have been taken from Poirier and Charpy, or from LeDouble.

Schmorl is frequently credited with having demonstrated in two children at postmortem examination the defect of the neural arch and, therefore, to have shown that its origin could be congenital[34]. Actually the report is not entirely clear on this point. The findings presented by Schmorl consist of the following: The first specimen was taken from the vertebral column of a child two and one-half years old. The vertebra in question presented a deep groove in the left pars interarticularis, but the continuity was not completely interrupted. This, then, is not a neural-arch separation, although it is suggestive of a predisposing condition. A normal pars interarticularis was present on the right side. The second specimen was from the vertebral column of a two-year-old child and showed a cartilaginous portion still undergoing ossification in the isthmal region of one side, which is an equivocal finding. Willis, in his discussion of serial sections of an ossifying neural arch, pointed out the possibility of cutting through the dumbbell-shaped center of ossification in the neural arch in such a manner that two centers of bone with nothing but cartilage between them are shown in the section. Yet, after examining all sections, he had no doubt that bone made contact with bone in all cases studied. In Schmorl's paper the photomicrograph leaves no doubt that there was union of bone with bone around the ossifying cartilaginious "rest" (page 424). It is suggested that the findings in Schmorl's two cases are not conclusive.

In contrast to the foregoing, there are a number of studies in which conscientious search had failed to reveal two centers of ossification located in positions which might give rise to a separate neural arch. Hayek studied an unspecified number of foetus and failed to observe more than one center of ossification in each half of any arch. LeDouble, as already noted, found no double centers in the specimens which he himself examined. Junghanns (quoted by Chandler) is said to have had the same experience. Willis, having failed to demonstrate such a pattern grossly, continued his search microscopically with serial sections, but was unable to demonstrate two centers for one half of a neural arch. He did report bilateral anomalous centers in a last lumbar vertebra of a full-term foetus, which were located in the anterior portion of the neural arch adjoining the neurocentral synchondrosis, but anterior and cephalad to the superior articulating process. Such a variation could not be the basis of a separation at the site of a separate neural arch.

Excellent reviews of the literature on all phases of the subject of separate neural arch have been written in recent years by Chandler, Friberg, and Thieme. There are isolated cases in which the etiology of a separate neural arch has been determined[5,15,22,56,57], but these cases are infrequent and the great majority remain unexplained. Numerous articles may be found concerning the incidence of the lesion in skeletal material[16,20,28,29,41,49,60,64,66,68,70]; several describing soft-tissue structures surrounding the lesion[15,18,52,58,70]; and, from the clinical standpoint, many suggesting therapy[6,11,14,17,30,33,44,65,71].

If the separate neural arch is an acquired rather than a congenital condition, it is reasonable to expect a period during the life span of an individual when the arch is not separated, followed by a period in which it is separated. Thus, if the arch becomes separated at approximately the same age level in most individuals, a study of the incidence of this defect in a population will indicate its time of appearance. On the other hand, if the arch becomes separated at varying ages in different individuals, a study of incidence in a population should present an increase in incidence with increase in age. The purpose of this paper is to test this assumption by determination of the incidence of neural-arch separations in the foetal and neonatal periods, in childhood, and in maturity extending into senescence. The study was divided into three phases: first, investigation of foetal material and cadavera of stillborn infants; second, observation of a large number of adult skeletons of varying ages from the Terry Anatomical Collection of Washington University and the Todd Anatomical Collection of Western Reserve University; and third, study of a series of children by means of roentgenographic examination.

METHOD AND RESULTS

Cadavera of Foetus and Stillborn Infants

Examination was made of cleared and stained human foetus, prepared and reported by Woo, aged from about ten weeks of gestation to term. Twenty specimens showing the presence of well formed centers of ossification for the lateral halves of the neural arch were examined grossly. Neither accessory nor double centers were found.

Dissections were carried out on the cadavera of fifty stillborn negro infants (twenty-five males and twenty-five females) varying in age from approximately six months of gestation to term. The lumbar vertebrae were exposed in each case through a posterior mid-line incision and the vertebrae were examined after periosteal and perichondral elevation. Although the spinous process is not yet ossified in specimens of this age, the isthmal region was found to have osseous continuity in each case, and careful probing failed to demonstrate any groove, defect, or cartilaginous rest. In one specimen (approximately seven and one-half months' gestation) two accessory centers were discovered.[59] They were located in the right inferior articular process of the second and third lumbar vertebrae and have been interpreted as bearing no relation to a separate neural arch, since bony continuity extended from the superior articular process to the base of the spinous process. A similar case was discovered by Batts in his examination of 200 foetus. In view of the report by Hitchcock that neural-arch separations have been produced by manipulation of the newborn, flexion, extension, and lateral bending were carried out on several dissected specimens. All efforts failed to produce a fracture through the isthmal region. The experiment was repeated on three additional unembalmed specimens (one negro male, one white male, and one negro female) which had been kept in a frozen state throughout the entire postmortem period of at least one month. After they had been thawed, flexion in each case was carried out until the pubic region was brought into contact with the abdomen. In one specimen hyperextension to the extent of producing contact between the sacral and upper lumbar regions, as well as lateral bending and flexion, was forced. In no instance was a fracture through the isthmal region produced. However, it must be remembered that the conditions pertaining to a cadaver are quite different from those in a living infant.

Adult Skeletons

The study of skeletal material consisted of the examination of 4,200 vertebral columns of American whites and negroes of both sexes[60]. Briefly, the findings were that, although the incidence of separate neural arch varied with ethnic group and sex, it remained constant with age (within the limits of error) between the years of twenty and eighty. Skeletons in the age periods outside this range were too few to justify conclusions concerning incidence.

Skeletons of Children

The study of children was limited to roentgenograms of the living. Two series of subjects were examined. The first series included forty children between three and six years; fifteen were white males; thirteen, white females; nine, negro males; and three were negro females. These children had been seen at the Out-Patient Department of the St. Louis Children's Hospital for various complaints of a general pediatric nature. No defect in an isthmus was discovered.

Since it had been found that the white male adult skeletons presented the separate neural arch most frequently, roentgenograms on a second series of 100 children limited to white males were made. Subjects from the St. Louis Children's Hospital Clinic were obtained in the same manner as were those in the first series. In addition, children who were pupils at the St. Louis Central Institute for the Deaf and children who were residents at two orphanages served as subjects. Anteroposterior, left posterior oblique, and stereographic right posterior oblique roentgenograms of the lumbosacral area were made of each child; additional roentgenograms were made of those who presented any suggestive findings. In this second series no selection beyond the institutional connection was made and all available boys in the age range from three to sixteen years were studied. Twenty-eight in this series were congenitally deaf, and in fourteen others the deafness, of known or unknown etiology, was acquired. One child had a congenital sensory aphasia, but the others were "normal" in outward appearance and so far as their history indicated. In view of the known tendency of several congenital defects to occur in the same person [26, 69], neural-arch separations, if they are of congenital origin, might be expected to occur more often in the congenitally deaf children.

The distribution of subjects and the incidence of the defect according to age was as follows:

Age in Years	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No. of Boys	1	4	9	13	9	8	14	7	9	8	7	7	3	1
No. of Defects	0	0	0	0	0	0	3	0	0	0	0	0	0	0

Since nine years was both the median and the mean age of the children and since this series had a statistical base of only 100 so examined, no conclusions regarding relative incidence can be acceptably deduced therefrom. Only three defects were found in the 100 children examined, and of these, two were found in the "normal" group whereas only one was found in the group of congenitally deaf children.

DISCUSSION

Since the examination of twenty cleared and stained human foetus and fifty-three stillborn infants failed to reveal a single instance of double centers of ossification in one side of a neural arch, the literature was searched for findings of previous workers in this field. As can be seen from Table I, recorded observations of 509 foetal specimens and

TABLE I

SUMMARY OF INVESTIGATIONS OF SEPARATE NEURAL ARCH IN FOETAL AND NEONATAL CADAVERA

Investigator	No. of Specimens Examined	No. of Defects Found
Batts	200	0
Chandler	18	0
Friberg	18	0
Hitchcock	90	0
Mall	about 60	0
Noback	40	0
Sensenig*	9	0
Present Series	73	0
Total	509	0

* The actual number of specimens studied by Sensenig was eighty-eight, but only nine of the specimens were large enough to show ossification centers in the vertebrae, that is, fifty millimeters and longer.

cadavera of newborn infants were found. In none of these instances were double centers of ossification found for either half of the neural arch. Each investigator listed in Table I undertook the examination of foetal spines as part of his research on the separate neural arch, excepting Mall, Noback, and Sensenig.

On the basis of the fact that the examinations of 509 foetal specimens and cadavera of stillborn infants have not revealed a separate neural arch or any detectable precursor of one, it can be determined statistically what the chances are that this lesion was present but not recognized. It is known that the percentage incidence of the lesion varies with ethnic group and sex [60], being greatest in the white male (6.4 per cent.) and least in the negro female (1.1 per cent.). For the sake of a wide margin of accuracy in making the following calculations, it was assumed that the level of incidence is 2 per cent. If the lesion is congenital and therefore as frequent in the foetus as in the adult (calculated at a 2 per cent. level of incidence), there is less than one chance in 30,000 that the above results (509 negative observations) could occur. If calculated at a 5 per cent. level of incidence, the chances of error become one in more than two hundred billion.* These calculations have been made by the same method as that employed by Batts and strongly suggest exclusion of the possibility that the separate neural arch has a congenital origin.

The study of 4,200 lumbosacral columns [60] revealed that, although the incidence varied with ethnic group and sex, it remained constant within the limits of error between the years of twenty and eighty.† In the series of 4,200 white and negro columns there are too few in the younger decades to warrant a breakdown into five-year intervals. The evidence available, however, indicates that the genesis of separate neural arch in American whites and negroes probably occurs before twenty years of age and in Eskimos before thirty years of age.[67]

Statistical analysis cannot be properly applied to the studies on incidence and age in adult material made by Willis and Friberg because the factors of ethnic group and sex were not taken into account. A review of the figures presented by both Willis and Friberg shows clearly an increased incidence in the upper age groups as compared with the lower. Willis' figures were derived from his study of 1,520 skeletons from the Todd collection. He compared the age incidence of the separations in this entire group of skeletons with the age incidence of the first 626 skeletons which he examined [while the text states 625, the figures total 626] and presented the result in graphic form. It is readily seen why these figures cannot be subjected to statistical analysis, but even without statistical methods it is apparent from the figures on his graph that under the ages of fifty years there were 349 skeletons and thirty defects. This would give an incidence of 8.5 per cent. if the groups were similar. There were 277 skeletons of men and women over fifty years of age and forty-six defects — an incidence of 16.6 per cent. Separate neural arch is therefore shown in this series to be twice as common after the age of fifty as before. However, these findings are due to an accident in sampling, since in both the Western Reserve Collection and the Terry Collection the younger age groups are heavily weighted with negroes (among whom the incidence of separate neural arch is relatively low) and the older age groups are composed largely of whites (among whom the incidence is relatively high). Friberg's figures were derived from all the roentgenograms of the lumbar portion of the spine made at the *Vanföreanstalten* in Stockholm from January 1, 1936, to December 31, 1938. Of the 1,161 patients forty years of age and under, fifty-five, 4.7 per cent., presented a separate neural arch; whereas those forty-one years of age and over constituted a group of 673 with fifty-one defects, 7.6 per cent. This increase would be statistically significant

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* The probability is determined from the binomial distribution. The appropriate term for determining the probability that exactly no cases would occur in 509 examinations when the probability of occurrence is 0.05 is evaluated thus: $(1 - 0.05)^{509} = (0.95)^{509}$. This amounts to a probability of one chance in 224,000,000,000.

† Since the publication of this result, Stewart[67], in his series of Eskimo and Aleut spines, has reported an increase in the incidence of the defect during adult life concomitant with the development of slight arthritis.

TABLE II

SUMMARY OF INVESTIGATIONS CONCERNING INCIDENCE OF SEPARATE NEURAL ARCH DETERMINED BY ROENTGENOGRAMS

Investigator and Year	Reason for Roentgenographic Study	No. of Cases	Defects Found	Percentage of Defects
Hodges and Peck, 1937	Back pain with sciatic radiation.	447	46	8.1
George, 1939	Symptoms referable to the lumbar spine.	3,301	115	3.5
Friberg, 1939	Made in hospital. No reason given.	1,834	106	5.8
Caldwell, 1943	Pain in low back.	152	15	9.9
Gallucio, 1944	Routine military examination.	142	15	10.6
Meschan, 1945	Examinations in overseas general hospital.	1,131	57	5.1
Lerner and Gazin, 1946	Pain in low back.	511	52	10.1
Rhodes and Colangelo, 1946	Roentgenographic examinations in an Army hospital during a one-year period.	1,250	60	4.8
Bailey, 1947	Examination of unselected inductees.	2,080	91	4.4
Bailey, 1947	Examination of patients in whom spondylolisthesis was suspected.	2,080*	29–50 per cent.†	

* This figure is excluded from the total because the number of defects found was not included.
† The number of defects found depended on the experience of the clinician.

if the groups were similar in composition. However, the distribution of ethnic group and sex in the two groups is not made known, nor the method of selection of the patients. Most of the children were x-rayed because of "scoliotic conditions", but no information is given to explain why the adults were examined, and they may well have had complaints referable to the low back. Thus the increase in incidence of separate neural arch with increase in age in the reports of Willis and Friberg cannot be shown to be statistically significant.

The incidence of the separate neural arch as determined in the unselected population of 4,200 skeletons correlates closely with that found by the roentgenographic examination of clinical material (see Table II). Exact correlation of these figures cannot be expected since patients examined because of low-back pain were included in the second series. This selection should increase the number of positive demonstrations, if the lesion under discussion is significant in the production of back pain. Evidence has been presented both for and against this concept [17,27,32,36,47,53], but special reference is made to the two series of roentgenograms presented by Bailey and included in Table II. Moreover, the difficulty in demonstration of some of the lesions must certainly be taken into consideration when roentgenographic methods are used [7,9].

Twelve cases of neural-arch separation in children under the age of ten have been found in the literature [7,8,12,23,25,31,37,45,71], but these are certainly very few as compared to the large number of adults reported with the lesion (see Meyerding [44]). The present observations on children constitute an attempt to bridge the age gap between foetal and neonatal material and adult material. They have shown a percentage incidence of 3, which places the incidence of this age group mid-way between that of 0 per cent. at birth and 6.4 per cent. in the adult white male. Unfortunately, the number of white male children examined in this study is not enough, for, although the findings are very suggestive, statistical testing indicates that the difference in incidence between the children and the adults may not be significant. Observations on a group of white males repeated at regular intervals from the age of three until thirty should give conclusive evidence for the age of onset of the separation. White males are specified because they present a greater incidence than other available ethnic and sex groups, and the age of three years is suggested for the beginning because children of this age are usually cooperative enough for examination, and the bone is sufficiently ossified to be clearly demonstrable by roentgenograms, A recent provocative monograph by Roberts recalls the theories of Meyer-Burgedorff and Lane suggesting that strain de-ossification may be the cause of the separation by a mechanism similar to that of the fatigue or "march" fracture [10]. This might very well occur during the formative years or perhaps even later, with the onset of manual labor. Thieme's conclusion that this defect is related to the lumbar curve and upright posture may be interpreted as support for this line of reasoning. Meyer has stated that he is able to see in roentgenograms areas of increased and decreased densities in the isthmus, followed by gradual fragmentation and dissolution leading to neural-arch separation. The process is described as resulting from chronic trauma and as being similar in nature to that suggested by the observers referred to above.[43] It appears, therefore, that the lesion is an acquired one, but the manner in which it is acquired is not yet understood.

SUMMARY AND CONCLUSIONS

1. All well documented embryological and foetal studies within recent years have failed to demonstrate a defect suggesting separation of the neural arch. There is therefore no proof that the lesion is congenital.
2. Attempts to produce separation of the neural arch by manipulation of stillborn infants have failed; thus birth injury is not believed to be a significant cause. Paucity of the lesion in young children supports this contention.
3. Examination of a large series of skeletons has shown that the incidence of the defect does not increase during the age period from about twenty to eighty years.
4. Roentgenograms of a series of children have revealed an incidence of defects mid-way between the frequency in the adult and the total absence at birth. This is a suggestive but not a conclusive finding, because the number of subjects was too small to yield statistically significant results.

NOTE: The authors wish to thank Dr. J. K. Woo for making available the twenty foetus used in this study.

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PATHOLOGICAL ANATOMY IN TALIPES EQUINOVARUS

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ETIOLOGY

The primary cause of congenital club-foot has not been established. Abnormal pressure *in utero*, endogenous maldevelopment, and malnutrition have been mentioned as causes. One of the oldest theories implies the presence of a neuromuscular contracture of unknown origin. Another possible cause of the deformity is local arrest of development, maturation of the foot becoming stationary as the foot passes through one of its developmental phases. Willis pointed out that feet normally pass through stages of adduction of the metatarsus, varus, and equinus during the first four months of embryonic life. On the other hand, Bessel-Hagen denied the existence of physiological club-foot in the embryo. Max Böhm studied six feet in the first half of the prenatal period, from six weeks to three and one-half month's gestation, and one case of bilateral club-foot in a seven-month foetus. He concluded that a severe club-foot resembled the foot of a two-month embryo. A controversy still to be settled is whether the primary lesion of club-foot is to be found in the soft tissues or in the skeleton. Burrell in 1893 reported his findings on dissection of a congenital club foot and demonstrated shortening of the posterior tibial muscle. In a study of two foetus by Bechtol and Mossman, failure of muscle growth to keep pace with skeletal growth was suggested.

DISSECTION STUDY IN A CASE OF CONGENITAL TALIPES EQUINOVARUS

A premature infant, born at six and one-half months, had talipes equinovarus on the left and a normal right foot. For anatomical comparison the feet were dissected prior to tissue fixation.

The skin and subcutaneous tissue were removed. The deltoid ligament, with its origin from the medial malleolus and attachment to the talus, calcaneus, and navicular bones, was identified. It did not appear shortened and offered no resistance to correction of the varus. No part of the capsule of the ankle joint was thickened. A striking difference was noted between the right and left Achilles tendons in that the tendon on the involved side was two centimeters longer and inserted more medially into the tuberosity of the calcaneus (Fig. 1). Moreover, it had a dense white appearance as compared with the glistening smooth gray of the normal tendon. The over-all length of the triceps surae was not determined.

About two thirds of the tendon of the anterior tibial muscle of the club foot inserted into the base of the first metatarsal bone medially, and the remainder was attached to the medial border of the first cuneiform. This was the same in the normal foot. The tendinous portion of the anterior tibial muscle of the club foot was found to be one centimeter longer than the corresponding tendon of the normal foot (Fig. 2). The over-all muscle length was not determined. The anterior tibial muscle was the only structure which offered abnormal resistance to eversion. After this tendon had been sectioned, the foot could easily be brought to the normal position.

The posterior tibial muscles inserted into the navicular tuberosity in both feet and appeared similar in all respects. An obvious difference was noted between the peroneal muscles of the club foot and those of the normal side. The muscle mass of the peroneus longus and peroneus brevis in the club foot was grossly only about one half the size of that

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Fig. 1: The Achilles tendon of the club foot was inserted more medially into the tuberosity of the calcaneus. The same tendon was also found to be longer in the club foot.

Fig. 2: The anterior tibial tendon of the club foot was one centimeter longer than that of the normal foot. It was the only structure which offered resistance, however, to eversion of the foot.

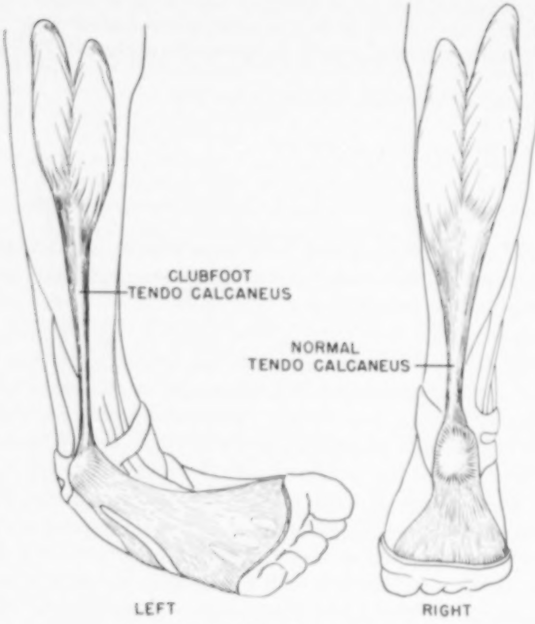

Fig. 1

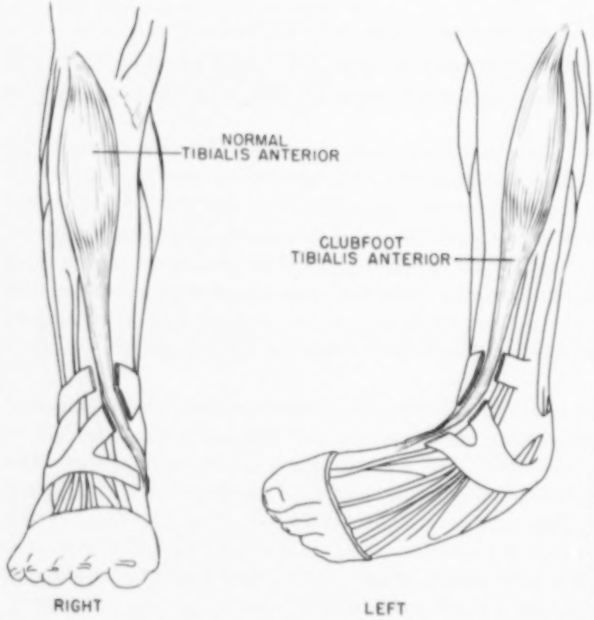

Fig. 2

of the normal peronei (Fig. 3). The insertion of the peroneus longus was traced to the plantar surface of the base of the first metatarsal and the first cuneiform bones bilaterally. Both short peroneal muscles inserted into the dorsolateral surface of the base of the fifth metatarsal bone.

The head and neck of the talus in the club foot were prominent dorsally and were directed toward the fifth metatarsal. Ossification centers were present in the calcaneus, cuboid, talus, metatarsals, and phalanges. The contour and relative size of the individual bones in the two feet appeared identical.

The length of the muscle fiber was determined by teasing out muscle fibers under the dissectoscope. The individual muscles were removed, a longitudinal and a partial cross section were taken for microscopic study, and the remainder were anchored beside a millimeter scale under the dissectoscope. It was noted that the more distal fibers usually inserted into the tendon distally. For the most part, the fibers extended the entire length of the muscle. Because of the small size of individual muscle fibers, groups or fasciculi were teased out for measurement. Muscle-fiber length in the club-foot peroneals was thirteen to fourteen millimeters, and in the normal foot ten to twelve millimeters. Anterior tibial muscle fibers measured fifteen millimeters in the club foot and seventeen millimeters in the normal foot. The diameter of the muscle fibers of the peroneal, anterior tibial, and gastrocnemius muscles of both feet was around sixty-seven micra. In phosphotungstic-acid stains the striations in the anterior tibial muscle of the club foot were somewhat paler than those of the opposite side, and no areas of fibrosis were seen in any of the sections. Hematoxylin and eosin as well as Masson stains were used. Microscopically, the peripheral nerves appeared normal.

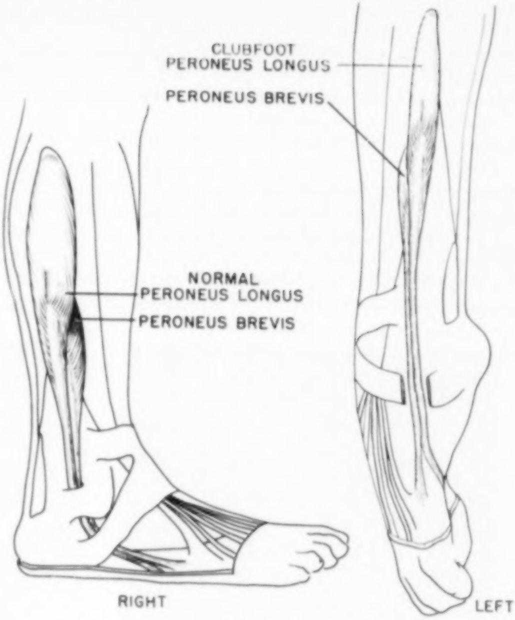

FIG. 3

The peroneal muscle mass on the side of the club foot was scarcely one half that of the normal extremity.

COMMENT

The findings suggest that in this case a primary imbalance existed between a strong anterior tibial muscle and subnormal or agenesic peroneals. Osseous changes in this type of club-foot would seem to be secondary to muscle imbalance. All observed muscle fibers were of approximately the same diameter; it may therefore be assumed that a portion of the peroneals of the club foot had failed to form. This would account for the comparatively small size of this muscle group. It has been shown that, in amyoplasia congenita or arthrogryposis, parts of muscles or even whole muscles fail to develop. Congenital club-foot may be a related or similar disorder resulting from imbalance of the muscles which insert in the foot. The Achilles tendon with its wide medial insertion into the calcaneus also played a role in causing or maintaining the deformity. Osseous changes, if they had developed in this foot, would probably have been secondary to muscle deficiency.

In 1888 Vincent-Jackson described good results from the immediate correction of congenital club-foot by sectioning the Achilles tendon and the anterior and posterior tibial tendons.

In cases similar to the dissected club foot here described, transplantation of the anterior tibial tendon to the lateral tarsus, as advocated by Garceau and Manning for recurrent club-foot, would seem worth while if permanent correction could not be obtained by the usual methods.

Correction by wedging would seem to imply stretching the anterior tibial and triceps surae groups, aligning the foot so that the peroneals could function and become hypertrophic. If, after several adequate trials, this does not produce permanent correction, transplantation of the insertion of the anterior tibial tendon to the base of the fifth metatarsal bone might be indicated.

In four of six cases operated upon by the author, the major insertion of the anterior tibial into the first metatarsal was more distal than normal. Fascial expansions from the anterior tibial tendon were also noted to extend medially, as well as laterally over the dorsum of the foot and the anterior aspect of the ankle. These abnormalities, together with other aberrant muscle attachments, have been noted by Stewart. Surgical section of the medial and anterior portion of the Achilles tendon, as advocated by Stewart, may be beneficial.

When basic knowledge from a larger number of early dissections of congenital club feet has been accumulated, better treatment of club-foot should become available.

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DISCUSSION

THE IMPORTANCE OF DIRECT SURGICAL ATTACK UPON LESIONS OF THE VERTEBRAL BODIES, PARTICULARLY IN POTT'S DISEASE

(Continued from page 25)

Dr. Dewar has asked some very pertinent questions, and we did not include the answers to them in the paper because we were watching the clock. We do not do punch biopsies for two reasons: I have a predilection for seeing where I am going and I am disinclined to use needles that are thick enough to get good biopsy material in the region occupied by the vertebral body. A typical costotransversectomy is not a difficult procedure. In the lumbar portion of the spine we have gone in either laterally, if a reasonably big abscess was present, or directly posterolaterally through the muscles and transverse process in certain instances. We had a very interesting case of that sort just last week; we encountered a thick caseous lesion in a fibrous capsule without finding anything that we feel could have been removed except by a very large trocar or with considerable suction. In the cervical region we have usually gone in laterally.

The question of improvement has been judged in general by the clinical appearance of the patients. They have not been shocked or troubled by the operation. We have, after definitive diagnosis in cases of tuberculosis, proceeded with grafting or fusion within the month, and these patients have tolerated both operations very well. Another feature of improvement we have noticed is the relief of root pain. We also feel that the surgical approach, while it is more difficult, does enable one to evacuate the paravertebral abscess. We use a soft catheter to explore the whole extent of the abscess when we enter it, and to wash it out; with very careful finger dissection a great deal of material can be evacuated. Particularly in the thoracic region where the drainage is difficult to secure, as it has to follow a long tract, we feel that we have eliminated a great deal of the caseous and tuberculous material at the time of operation and have left a collapsible cavity which has temporarily been partially distended with streptomycin solution. Consequently, we feel that there is a direct surgical as well as a diagnostic benefit from costotransversectomy.

One factor I would like to explain. The tremendous increase in reversals of diagnosis occasioned by this procedure in my regime over the past five years makes it look as though we didn't know much about diagnosing tuberculosis. It really is due to the fact that we see many of these patients quite early. Many of them come from the Medical Service; others are older people in whom malignant lesions are always a possibility and Hodgkin's disease and other inflammatory lesions are more common, and we have treated them very early.

DEFORMITIES OF THE HAND INCIDENTAL TO PATHOLOGICAL CHANGES OF THE EXTENSOR AND INTRINSIC MUSCLE MECHANISMS *

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Physiological function of the hand depends upon coordination between the intact intrinsic-muscle mechanism and the extrinsic muscles. Injury to any part of this system results in deformity. Trauma to the central slip of the extensor tendon, to the lateral bands anywhere along their course, or to the main dorsal hood leaves an imperfect digit. Ischae-

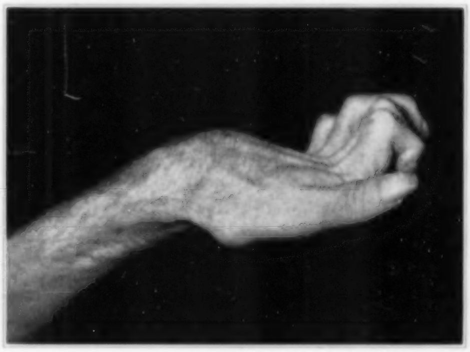

FIG. 1

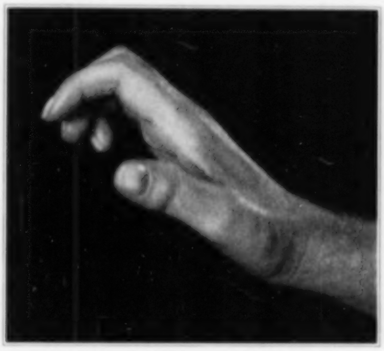

FIG. 2-A

Fig. 1: Claw-hand following low median-nerve and ulnar-nerve palsy. Infection and contracture at the wrist accentuated the over-pull of the extensors. The deformity was old. The skin, fascia, tendons, and other dorsal tissues were contracted. In spite of this, there was a good pinch and hook.

Fig. 2-A: A less severe claw-hand following high median-nerve and ulnar-nerve lesions. The over-pull of the extrinsic muscles was less pronounced. The power of the intrinsic muscles did not return, but the strength of the extrinsics was normal. Note the absence of extension in the middle and distal phalanges. The long and ring fingers had old mallet-finger deformities.

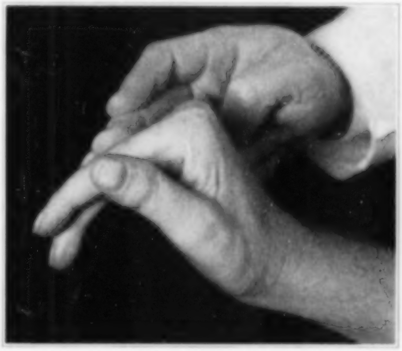

FIG. 2-B

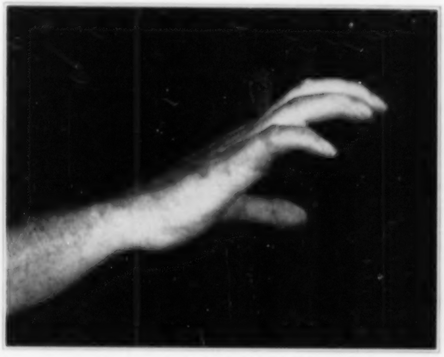

FIG. 2-C

Fig. 2-B: Through the stabilization of the metacarpophalangeal joints, extension of the distal phalanges was made possible. Replacement of the intrinsic motors must be done in order to give active extension at the middle and distal interphalangeal joints.

Fig. 2-C: A four-way split-sublimis transfer was done to the lateral bands of all the digits. There was an increase in extension at the proximal interphalangeal joints, an increase in flexion strength at the metacarpophalangeal joints, and a greater range of spreading of the fingers. The fixed mallet-finger deformities prevented full extension.

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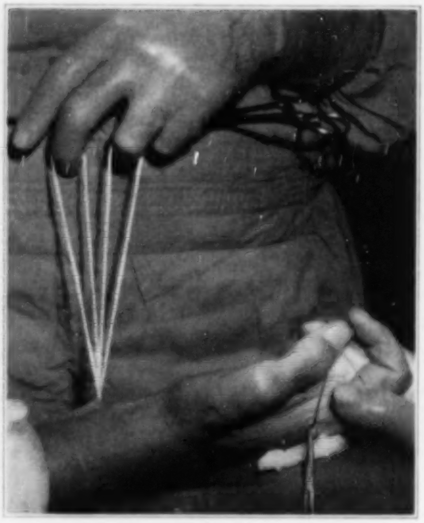

FIG. 3-A

The sublimis tendon from the ring finger was split into four segments. The first dorsal and volar interosseus tendon was isolated at the index metacarpophalangeal joint.

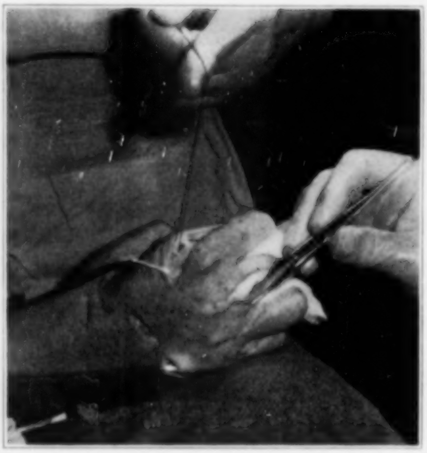

FIG. 3-B

The extensor indicis proprius and the extensor digiti quinti proprius were used to supplement the first dorsal interosseus and the abductor digiti quinti, while the split sublimis was attached to the lumbricalis segment of the lateral bands from the volar surface.

mic contracture of the intrinsic muscles or tendons, thermal contracture of the dorsal tissues, or contracture of the lateral bands or collateral ligaments leave typical changes in the hand. Roller injuries, in particular, result in severe damage to the extensor apparatus.

"INTRINSIC-MINUS" (CLAW) DEFORMITY OF THE HAND

Median-nerve and ulnar-nerve lacerations at the wrist result in paralysis of all the interossei, lumbricales, and thenar and hypothenar muscles. This paralysis allows external rotation and adduction of the thumb, loss of opposition, reversal of the concave surface of the palm, hyperextension of the metacarpophalangeal joint, and flexion of the distal joints. Flexion of the wrist resulting from cicatrix and infection accentuates the overactive pull of the extensors against the flexores sublimes and profundi (Fig. 1). In this "claw" position, without splinting, the skin contracts, the extensor tendons and dorsal fascia shorten, and the dorsal hood and capsule condense. Also, the collateral ligaments contract, the dorsal interossei act as extensors, and the volar capsule invaginates into the joint and adheres. All of this limits active or passive flexion of the metacarpophalangeal joints. Active splinting and early repair or replacement of damaged structures prevent these fixed contractures in the "intrinsic-minus" hand.

High median-nerve and ulnar-nerve lesions result in minimal clawing, because the unequal pull of the flexors and extensors is absent. As extrinsic motor power returns, the distal phalanges of the digits cannot be extended because of persistent intrinsic paralysis (Fig. 2-A). Pressure over the proximal phalanges replaces the stabilizing effect of the intrinsic muscles, and it allows extension of the distal segments by increasing tension of the long extensor mechanism (Fig. 2-B). Substitution for the intrinsic muscles (Fig. 2-C) can be made by splitting the sublimis tendon four ways and attaching the distal ends to the lateral bands (Figs. 3-A and 3-B). The tendon is sectioned at the proximal interphalangeal joint of the digit and is pulled out at the wrist. Each major segment is split longitudinally to within one inch of the muscle belly. A flexible probe is passed retrograde from an incision on the dorsal radial aspect of each proximal phalanx. This guides the tendon dorsal to the volar carpal ligament, along the course of the lumbrical muscle, volar to

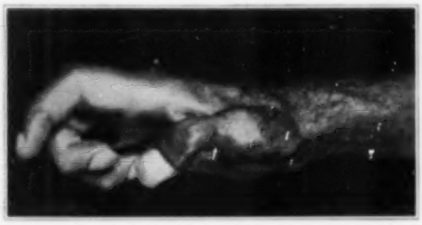

FIG. 4-A

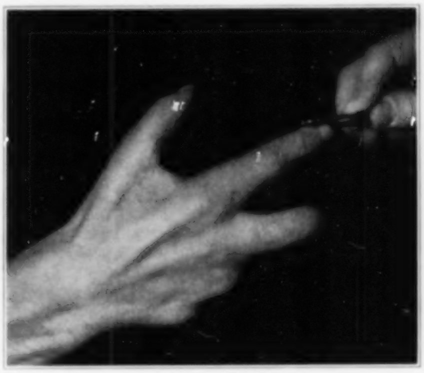

FIG. 4-B

Fig. 4-A: Severe contractures following an electrical burn. The ulnar nerve was irreparable. The median nerve was sutured; the web space was opened; the distal phalangeal joint of the thumb was fused; and the long and ring fingers were ankylosed in a functioning position.

Fig. 4-B: Pinch, grasp, and hook were restored by using the sublimis tendon from the amputated ring finger for an opponens transfer. The sublimis of the little finger was transferred to the first lumbricalis lateral band and the extensor indicis proprius was transferred to the first dorsal interosseus tendon. Better pinch and volar abduction is obtained if both weak components are replaced.

the transverse metacarpal ligament, and out the lumbrical canal. The split tendon is sutured under the proper tension to the lateral-band mechanism with interrupted sutures of braided wire. The main extensor tendon is avoided. In addition, the extensor indicis proprius is inserted into the first dorsal and volar interosseus, and the extensor digiti quinti proprius is attached to the abductor digiti quinti. These extensors are sectioned at the metacarpophalangeal joints, are pulled out at the middle of the dorsal surface of the hand, and are rerouted subcutaneously. The index tendon is looped under the volar and dorsal interossei tendons and is sutured to itself as well as

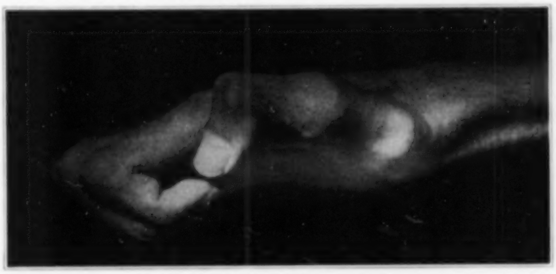

FIG. 5-A

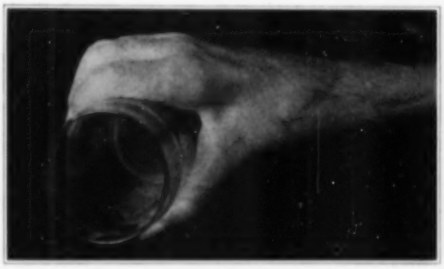

FIG. 5-B

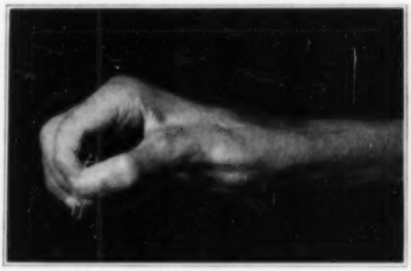

FIG. 5-C

Fig. 5-A: This deformity was the result of an irreparable brachial-plexus injury. Recovery of sensation was good, but motor power was poor. The sublimis and flexor pollicis longus muscles were 75 per cent. of normal. Note the acute flexion at the proximal interphalangeal joint, due to long-standing stretch and relaxation of the central slip which allowed the lateral bands to migrate to the sides of the joint. No motor was available for replacement of the intrinsics. The goal was grasp, pinch, and hook.

Fig. 5-B: An opponens tenodesis was done for the thumb; the wrist flexors were inserted into the finger extensors; and the sublimis tendons at the wrist were angled into the split profundi to give motor power at the tips. Following this, the proximal interphalangeal joints were fused; the carpometacarpal joint was stabilized; and the wrist was arthrodesed.

Fig. 5-C: A good pinch was obtained. It was not possible to use the criss-cross procedure for reinforcing the central slips.

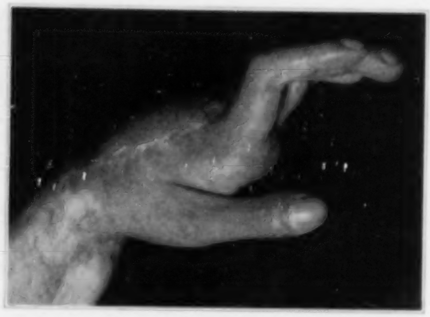

FIG. 6-A

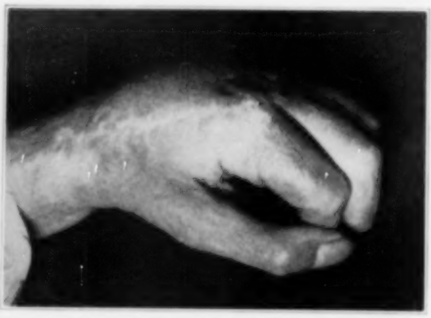

FIG. 6-B

Fig. 6-A: This was a severe claw hand following a crushing injury. The intrinsic strength was good. Wrist flexion and extensive cicatrix on the dorsum resulted in hyperextension at the metacarpophalangeal joints. The thumb was adducted. Attempts at correcting the hyperextension would have required advancement or replacement of an inadequate skin coverage and an extensive soft-tissue excision, followed by the replacement of the absent extensor tendons. In place of this extensive procedure, fusion of the metacarpophalangeal joints and shortening of the rays, as well as rerouting of the extensor pollicis longus, were done. A satisfactory grasp resulted.

Fig. 6-B: The finger flexors were active and the intrinsics allowed moderate extension at the interphalangeal joints. The metacarpophalangeal joints were stabilized by arthrodesis.

to the tendon. The hand is immobilized with the wrist and metacarpophalangeal joints in 30 degrees of flexion and with the interphalangeal joints completely extended.

A similar procedure is done on the little finger. The transfer for the little finger is done rarely. Experience has shown that greater strength in flexion and abduction has occurred and that a better pinch with the thumb has resulted when both the volar and dorsal substitutions are used for the index finger (Figs. 4-A and 4-B).

Following a brachial-plexus injury (Fig. 5-A), sensation may return, but scattered severe motor weakness persists and leaves the digits deformed. The thumb and other intrinsic muscles are paralyzed. The flexor digitorum sublimis group has good strength but is moderately contracted, since there is no strength in the extensor complex. Because of the constant flexion of the interphalangeal joints, there is gradual stretching and thinning of the central slip over the dorsum of the proximal joints; this allows the lateral bands to migrate to either side of these hinge joints. With acute flexion of the proximal interphalangeal joints, the distal phalanges continue to flex because of the absence of intrinsic power.

In the reconstruction of this hand, wrist tendons were made available for finger function by arthrodesis of the radius to the navicular, capitate, and third metacarpal; the carpometacarpal joint of the thumb was stabilized, because the extensor pollicis longus was weak and no replacement motor was available. A tenodesis was done for opposition. The extensor pollicis brevis was rerouted and was sutured to the palmaris longus at the wrist, the flexor carpi ulnaris being used as a static pulley. The sublimes were angulated into the split profundi at the wrist for active flexion of the distal phalanges. Fusion of the proximal interphalangeal joints with shortening of all the fingers improved the pinch and the grasp. The osseous fusions followed the tendon procedures (Figs. 5-B and 5-C). Arthrodesis of the wrist through a dorsal skin incision was done by splitting the distal portion of the radius in a horizontal plane and inserting an iliac-bone graft which extended from the radius to the second and third metacarpals. The carpal bones were cleaned of cartilage and roughened. Crossed Kirschner wires were used for internal fixation so that, if any additional tendon surgery were necessary, it could be done without disrupting the healing process.

Arthrodesis of the carpometacarpal joint was done by extending the transverse dorsal incision toward the thumb. The cartilage from this joint was excised; the thumb was placed in the position of opposition; and a wedge of iliac bone was inserted into the dorsal radial defect which occurred when the thumb was abducted. Crossed fine Kirschner wires gave rigid internal fixation.

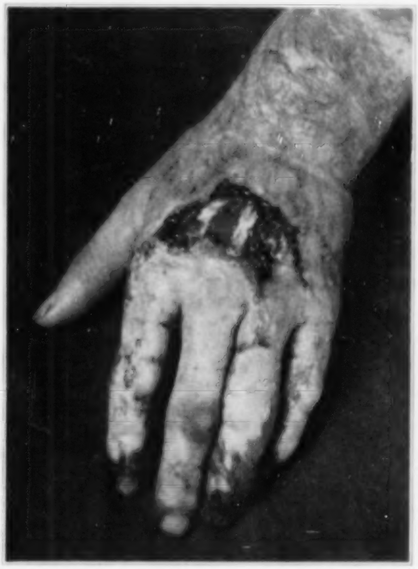

FIG. 7-A

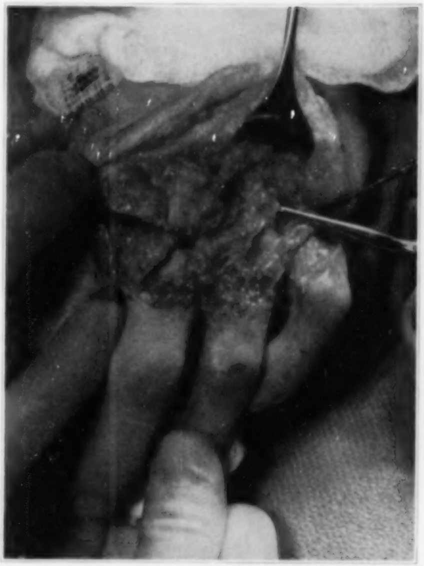

FIG. 7-B

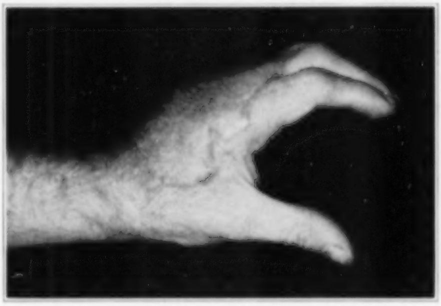

FIG. 7-C

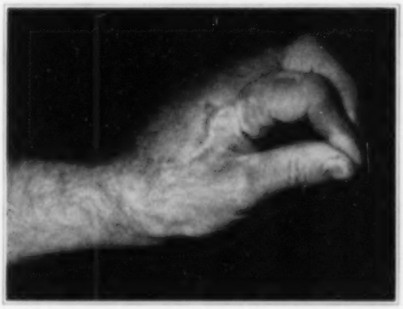

FIG. 7-D

Fig. 7-A: A roller injury caused severe damage to all the dorsal tissues and the joints of the hand. An abdominal flap was necessary to obtain coverage for the extensor tendons.

Fig. 7-B: In spite of the abdominal flap, massive cicatrix formed and there was poor delineation of the dorsal hood. All of the tissues were thickened and adherent to bone. It is not enough to excise collateral ligaments in this type of hand deformity for the correction of the extension deformity.

Fig. 7-C: After extensive excision of scar tissue and splinting for six weeks, very little improvement in metacarpophalangeal flexion was noted. The good spread was possible because of the relaxed thumb.

Fig. 7-D: There was a good pinch in spite of extension deformities at the metacarpophalangeal joints. The intrinsics were functioning. Fibrous ankylosis is a desirable goal when there is severe destruction of the extensor mechanism.

The proximal interphalangeal joints were approached from the dorsum, and the extensor mechanism was split vertically. A wedge resection of the joint, with the wide portion of the base to the dorsum, was done; bone fragments were placed around the fusion site and crossed pins were used for internal fixation.

If concomitant ulnar-nerve and flexor-tendon injuries leave the metacarpophalangeal joints contracted at 180 degrees, it is not likely that correction of the extension contractures will be maintained unless substitution procedures can be done. If the intrinsic muscle mechanism cannot be replaced by tendon transfer and if the metacarpophalangeal joints are not hyperextended, it is advisable to leave the extension deformity without attempting excision of the collateral ligaments.

EXTENSION CONTRACTURE OF THE HAND DUE TO DIRECT TRAUMA

Avulsion, crushing, or thermal injury involving the dorsum of the hand can result in a claw-hand deformity, secondary to scarring of the dorsal structures (Fig. 6-A). In this kind of injury with diffuse destruction of all tissues, correction of long-standing hyperextension at the metacarpophalangeal joints is difficult. When the pathological condition is so severe, attempts at releasing the collateral ligaments, stripping the dorsal fascia, and supplying additional skin coverage will not give a good result. Fusion of the metacarpophalangeal joints and shortening of the ray will alleviate the necessity of replacing inadequate skin coverage and permanently damaged extensor tendons (Fig. 6-B). Active motion in the interphalangeal joints is a prerequisite for this procedure.

Severe roller injuries (Fig. 7-A) may cause such extensive destruction of dorsal tissues that restoration of even a fair range of motion in the metacarpophalangeal joints is not possible. Good coverage is obtained by an abdominal flap and efforts at correction of joint and other contractures should be started as soon as possible. After the flap matures on the dorsal surface of the hand, it is elevated surgically (Fig. 7-B). The rigid contractures are found to be the result of adhesions of the extensor tendons, the deep fascia and periosteum, the joint capsule, the collateral ligaments, and the volar plate. If the injury is of recent occurrence, a thorough dissection and resection of scar tissue is done. In this hand, slight increase in motion was obtained in the metacarpophalangeal joints of the index finger and the long finger (Fig. 7-C), but no improvement was noted in the ring and little fingers, despite fixed and elastic splinting, with the fingers in acute flexion, for six weeks. Even though the extensor strength was poor, the action of intrinsic and flexor mechanisms was not enough to prevent the proximal phalanges from drifting into extension. The excessive regeneration of cicatrix caused a moderate recurrence of the deformity (Fig. 7-D). Osseous fusion of the metacarpophalangeal joints was not necessary, as it had been in the hand shown in Figure 6-A, because hyperextension did not occur and because a few

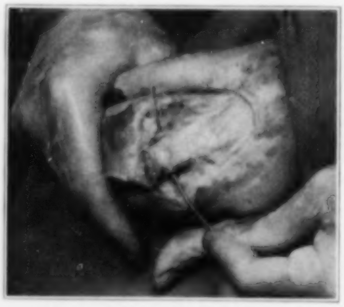

FIG. 8-A

Fig. 8-A: In roller injuries, the extensive cicatrix involves all tissues from the skin to the bone and is a greater factor in the fixation of the contracture than is the shortening of the collateral ligaments.

Fig. 8-B: The cicatrix seen in Fig. 8-A was excised, and a full-thickness flap was applied to the dorsum. Good passive joint motion was restored. The intrinsic muscles had fair power. Free tendon grafts were inserted in the deep fascia over the proximal phalanges. If joint function can be restored, such replacement of extensor power results in a stronger grasp.

Fig. 8-C: The role of contracted skin in producing extension deformity must be emphasized. After the collateral ligaments had been excised and the dorsal fascia had been incised, flexion of the metacarpophalangeal joints was limited until a semicircular incision was made in the skin, and the skin flap was dissected.

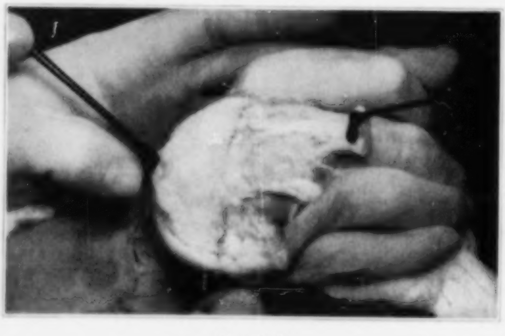

FIG. 8-B

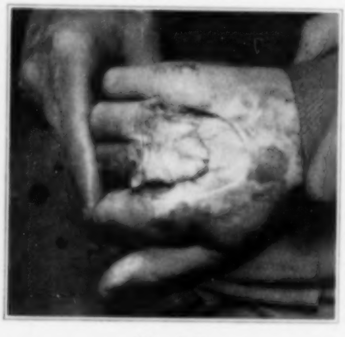

FIG. 8-C

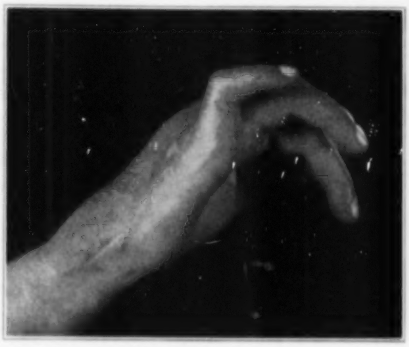

FIG. 9-A

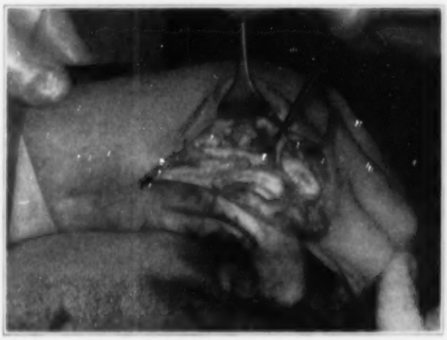

FIG. 9-B

Fig. 9-A: A severe roller injury resulted in hyperextension of the ring and little fingers. A full-thickness pedicle flap replaced necrotic skin. The extensor tendons to the little finger were intact but were contracted. The extensors of the other digits had been destroyed on the dorsum, but the segments which make up the dorsal hood were intact. Since the joints were not damaged, it was possible to release the contractures by the elevation and advancement of the skin flap and the release of the dorsal fascia, extensor tendons, and volar ligaments.

Fig. 9-B: After the flap had been raised, the extensor tendons to the little finger were seen clearly. The massive cicatrix which involved the distal ends of the extensor tendons and all of the deeper tissues attached to the bone were elevated. They were later excised. It was not enough to remove the collateral ligaments.

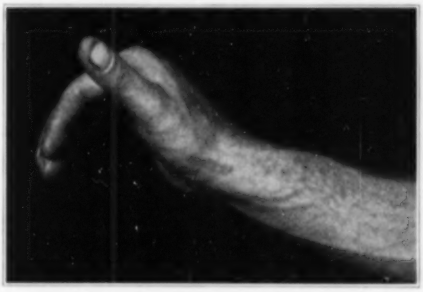

FIG. 9-C

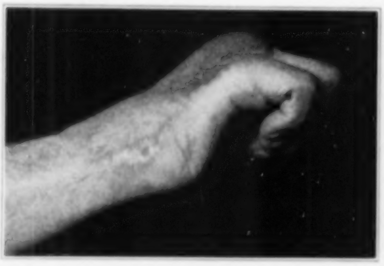

FIG. 9-D

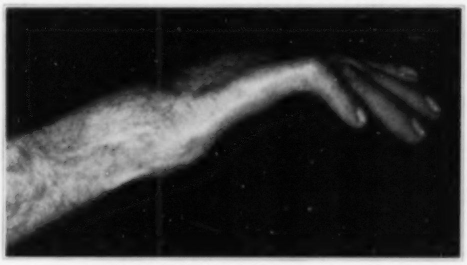

FIG. 9-E

Fig. 9-C: After six weeks of splinting with the fingers in flexion, the extension contracture was improved. It was then possible, since there was passive extension to 180 degrees, to replace the damaged extensor tendons by free grafts.

Fig. 9-D: The end result in flexion and the increased range of motion at the metacarpophalangeal joints are shown. The grasp was strong because the extensors were active.

Fig. 9-E: The extensor digitorum communis motor had been supplemented by the extensor carpi radialis longus. Extension to 180 degrees at the metacarpophalangeal joints was done with ease. The flexion deformity at the proximal interphalangeal joint of the little finger is congenital.

degrees of flexion and extension remained in spite of the partial fibrous ankylosis. When the dorsal hood is destroyed and the dorsal tissues are severely damaged, fibrous or bony fusion of the metacarpophalangeal joints in a functioning position is a desirable result, particularly if the interphalangeal joints have adequate function.

If the dorsal hood and extensor tendons have been destroyed (Fig. 8-A), but good passive extension and active flexion can be restored by releasing cicatrix, the tendons can be replaced by attaching free tendon grafts to the deep fascia or bone at the proximal phalanx (Fig. 8-B). This procedure may add more strength to the grip, increases the range of grasp and pinch, and occasionally eliminates the necessity for fusion. If the dorsal hood

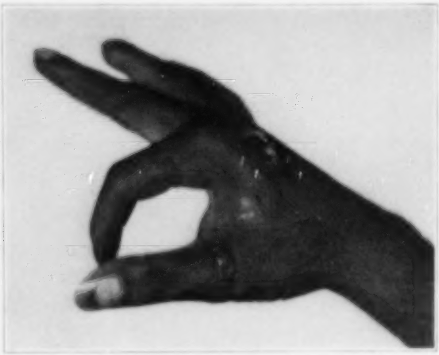

FIG. 10-A

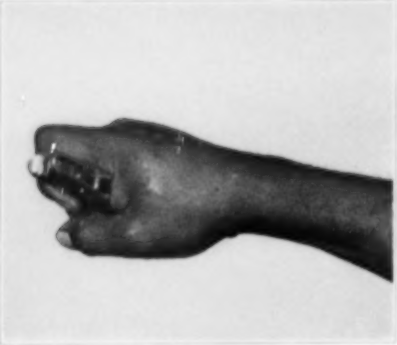

FIG. 10-B

Fig. 10-A: The fixed flexion deformity at the metacarpophalangeal joint of the index finger was the result of a hot crushing injury to the dorsum of this joint. Skin, tendon, and dorsal hood were destroyed. The joint was comminuted. Flexion deformity at the interphalangeal joints occurred.

Fig. 10-B: Instead of an attempt to reconstruct a damaged joint, as well as a joint which had only a remnant of the extensor mechanism intact, an arthrodesis was done, which fixed the large joint at 170 degrees. The partially intact lateral bands allowed adequate extension of the distal phalanges. A good, stable pinch resulted.

over the metacarpophalangeal joint has been destroyed, there remains little chance of an actively functioning joint resulting. The importance of cicatrix in the skin as a cause of extension contracture must be emphasized (Fig. 8-C).

If there has been adequate replacement of skin, if the dorsal hood is intact, and if segments of the avulsed extensor tendons remain (Fig. 9-A and 9-B), satisfactory excursion in flexion and extension can be obtained at the metacarpophalangeal joints, despite a severe injury. The first part of the reconstructive procedure includes the elevation of the flap, trimming redundant fat from the flap, and advancement of the flap, tenolysis of

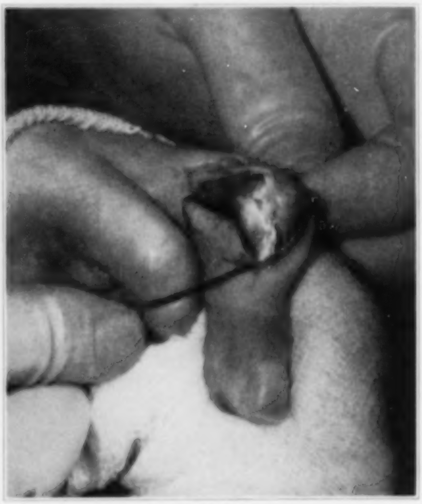

FIG. 11-A

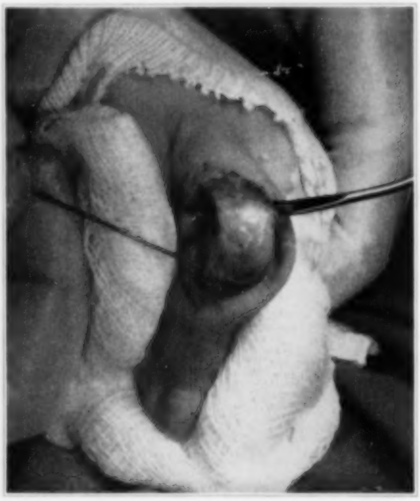

FIG. 11-B

Fig. 11-A: Long-standing flexion deformity of the proximal interphalangeal joint following a roller injury left a central extensor slip which was stretched but thick. The gliding surface had been destroyed. The distal probe is shown under the lateral band which had become adherent at the proximal joint. The upper probe freed the adherent extensor tendon. The distal phalanx was in a fixed hyperextension position, primarily because of the position of the lateral bands.

Fig. 11-B: The scarring of the extensor mechanism precluded the possibility of performing an arthroplasty or a soft-tissue replacement. Fusion and shortening of the digit gave adequate function.

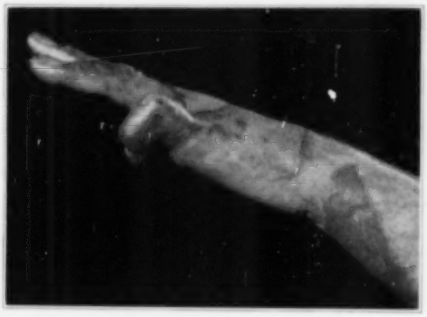

FIG. 12-A

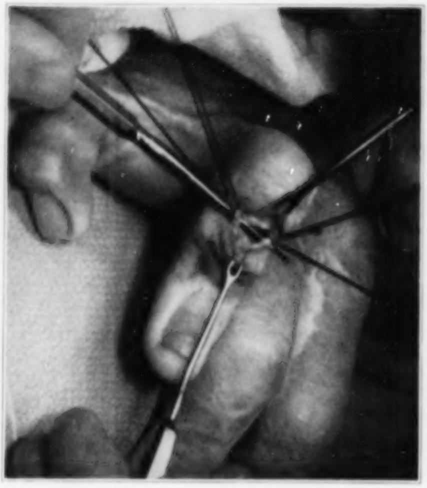

FIG. 12-B

Fig. 12-A: Thermal injuries resulted in extension contractures in spite of early skin coverage and adequate splinting. The little finger was fixed by contracture of the skin, the dorsal fascia, the collateral ligaments, and the shortened tendons at the metacarpophalangeal joint. Deep destruction of the tissues over the proximal interphalangeal joint resulted in infection and fibrous ankylosis. Extreme scarring on the volar surface prevented extension of the distal phalanx. A button-hole deformity was present in the ring finger. This became more obvious as flexion was attempted. The distal phalanx became hyperextended and prevented a good grasp.

Fig. 12-B: Because the skin on the dorsum of the ring finger would not allow tendon procedures, the lateral bands were isolated over the middle phalanx and were sectioned. It was necessary also to free them as far back as the middle joint, to cut the deep fascia and periosteum, and to dissect the distal attachment of the tendons into the distal phalanx. A split-thickness skin graft was used to fill the defect.

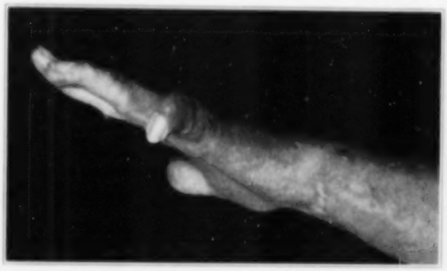

FIG. 12-C

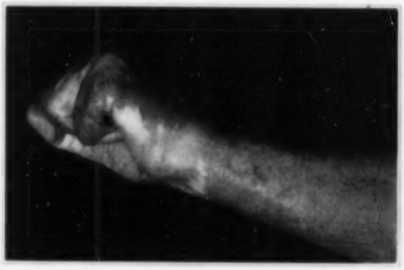

FIG. 12-D

Fig. 12-C: The ring finger could be completely extended at the proximal interphalangeal joint. The mallet-finger deformity in the ring finger is permanent, but it is not incapacitating. The patient's occupation required full flexion; this was not possible when the button-hole deformity was present. The preservation of the little finger was necessary. Function of this digit was improved by excising the proximal interphalangeal joint and arthrodesing the phalanges. The collateral ligaments at the metacarpophalangeal joint were excised; the tendons were dissected; the deep fascia was excised; and a split-thickness skin graft was placed on the dorsal and ulnar aspects after the abductor digiti quinti had been sectioned.

Fig. 12-D: The skin contractures on the dorsum were released and the defect was replaced with split-thickness skin grafts. This supplemented the other procedures in allowing a good grasp.

the distal portion of the extensor tendons, excision of the collateral ligaments and part of the dorsal interosseus tendinous attachment, excision of the dorsal fascia and its capsular attachment at the metacarpal neck, and elevation of the dorsal hood. Stripping of the volar plates, followed by forcible manipulation, then brings the proximal phalanges into flexion (Fig. 9-C). In order to prevent recurrence of the extension contracture, active splinting for at least six weeks is necessary. The wrist should be held in plaster, so that all the force of the rubber-band traction is concentrated at the metacarpophalangeal joints. Following reestablishment of active flexion and passive extension, tendon grafts may be inserted to replace the avulsed finger extensors. The extensor digitorum communis motor can be strengthened by the extensor carpi radialis longus (Figs. 9-D and 9-E). After toe-

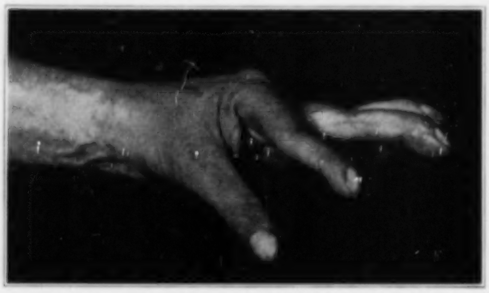

Fig. 13-A

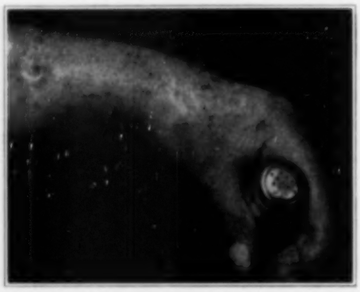

Fig. 13-C

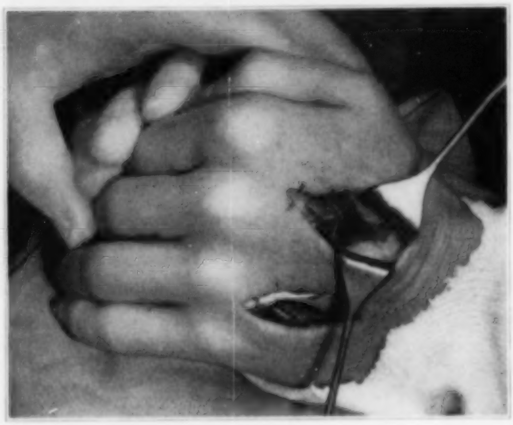

Fig. 13-B

Fig. 13-A: The "intrinsic-plus" hand. There was flexion deformity at the metacarpophalangeal joints, hyperextension at the proximal interphalangeal joints, and flexion at the distal phalangeal joints. The joints were in good condition. Ischaemic contracture had occurred in the interossei and lumbricales.

Fig. 13-B: The interossei were stripped from the metacarpals and the entire intrinsic mechanism was allowed to advance distally. This procedure did not loosen contracture of the lumbricales.

Fig. 13-C: Increased flexion at the interphalangeal joints was obtained. No change in the mallet-finger deformity occurred. Grasp and strength were improved.

extensor tendons have been inserted subcutaneously on the dorsum of the hand, they are sutured proximally and distally by the button-hole method. The extensor carpi radialis longus tendon is then sectioned at its insertion, is pulled out in the mid-forearm region, and is sutured to the common extensors at the musculotendinous juncture.

A severe injury to the dorsum of a single metacarpophalangeal joint, which results in skin loss followed by infection and destruction of the dorsal hood (Fig. 10-A), can be adequately treated by fusion of the joint in a position which is compatible with the occupation of the patient (Fig. 10-B). Because of fixed flexion contracture of the proximal interphalangeal joint, no effort was made to increase active extension at this joint. If the metacarpophalangeal joint has disintegrated, without loss of function of the interphalangeal joints, the main joint can be fused and a lateral-band transfer can be used to give full extension.

Technique for Release of Extension Contracture

Skin: If there is a pedicle flap on the dorsal surface of the hand, it must be advanced or the gap must be filled with split-thickness skin grafts when the joints are flexed. If superficial cicatrix is present and if the tendons are intact, the cicatrix may be excised and replaced by a split-thickness skin graft. If the extensor tendons are to be replaced, a pedicle flap must be used to replace scar tissue.

Extensor tendons and dorsal aponeurosis: These structures should be released by gentle dissection.

Collateral ligaments: An incision is made in line with the fibers of the dorsal hood. The collateral ligaments are identified with an anatomy probe, are grasped with a small straight clamp, and are completely excised with a cataract knife. A blunt probe is then

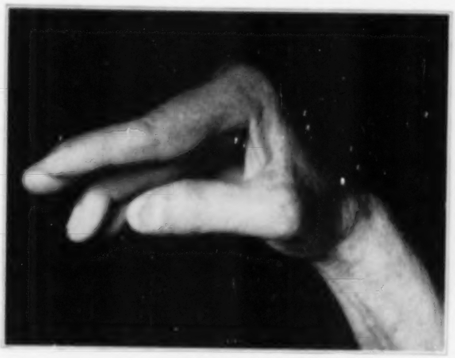

FIG. 14-A

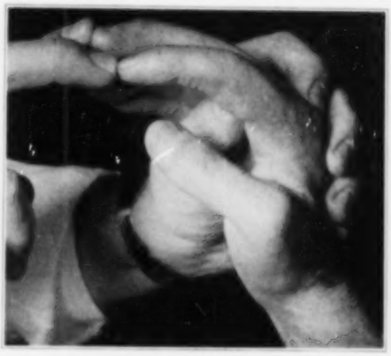

FIG. 14-B

Fig. 14-A: Contracture of the intrinsic mechanism occurred following diffuse tuberculous tenosynovitis on the flexor surface. The intrinsic muscles were affected and were shortened. Function was poor.

Fig. 14-B: In testing for the contracture of the intrinsic mechanism, the examiner made upward pressure on the proximal phalanges and attempted to flex the distal phalanges. Resistance was met.

Fig. 14-C: When the metacarpophalangeal joints were flexed, the intrinsic mechanism relaxed, tension on the distal phalanges decreased, and passive flexion was possible.

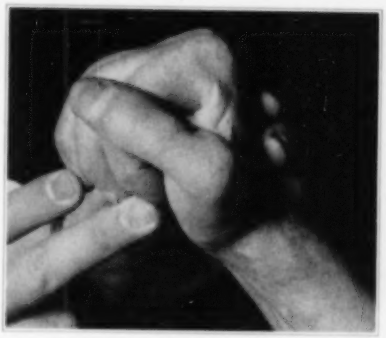

FIG. 14-C

inserted into the joint, intra-articular adhesions are freed, and the volar plate is stripped from the under surface of the joint. If adequate correction has not been obtained by forced hyperextension followed by flexion, then the deep fascia is incised and excised at its attachment to the dorsal capsule. Opening the dorsal hood parallel with the extensor tendon gives an excellent exposure of the collateral ligaments; this approach should be used when feasible. It is less desirable when there is abundant scarring over the dorsal hood and when difficulty exists in maintaining the integrity of the hood and tendon segment for later grafting. The transverse fibers of the hood, however, may be free of scar tissue, and the small horizontal opening can be repaired with one suture.

Lacerations of the lateral bands and central slip of the extensor tendon in conjunction with a compound comminuted fracture into the proximal interphalangeal joint can be treated by fusion of the joint in a position of function, little effort being made to repair the dorsal aponeurosis. Severe injury to the dorsal aponeurosis of the proximal interphalangeal joint, followed by spontaneous ankylosis of the distal interphalageal joint in hyperextension, can be treated by fusion of the proximal interphalangeal joint and shortening of the digit. The lateral bands are seen to be toward the volar surface of the proximal joint (Fig. 11-A); this position accounts for hyperextension of the distal phalanx. A scarred central extensor slip (Fig. 11-B) precludes any arthroplasty.

EXTENSION CONTRACTURE OF THE HAND DUE TO THERMAL INJURY

In the burned hand, multiple problems occur. The little finger frequently becomes abducted and extended as a result of extensor and flexor contractures and muscle pull (Fig. 12-A). This deformity can be improved by the excision of the collateral ligaments and the deep fascia and the freeing of the extensor tendons and the dorsal hood at the metacarpophalangeal joint. Section of the abductor digiti quinti followed by the application of a split-thickness skin graft on the ulnar side and on the entire dorsal surface of the hand increases the range of motion at all the metacarpophalangeal joints. An irreparable

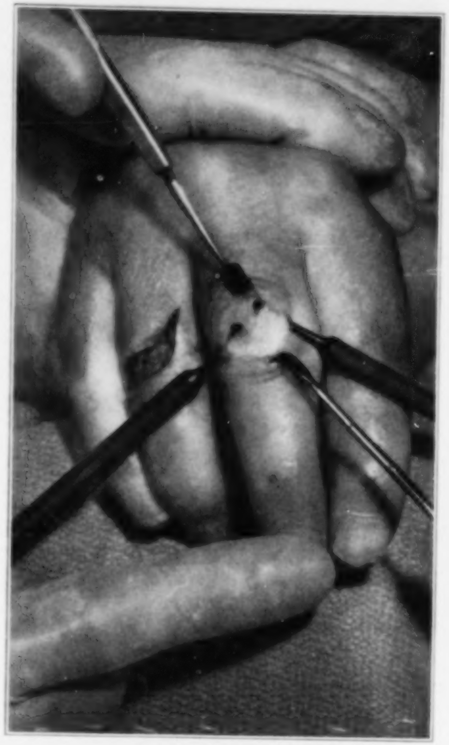

Fig. 15-A

The mechanism of the deformity was proved by exposing and dissecting out the lateral bands. At this time, there was upward pressure on the proximal phalanx, the lateral bands were on the dorsum of the proximal interphalangeal joint, and flexion of the distal phalanges was not possible.

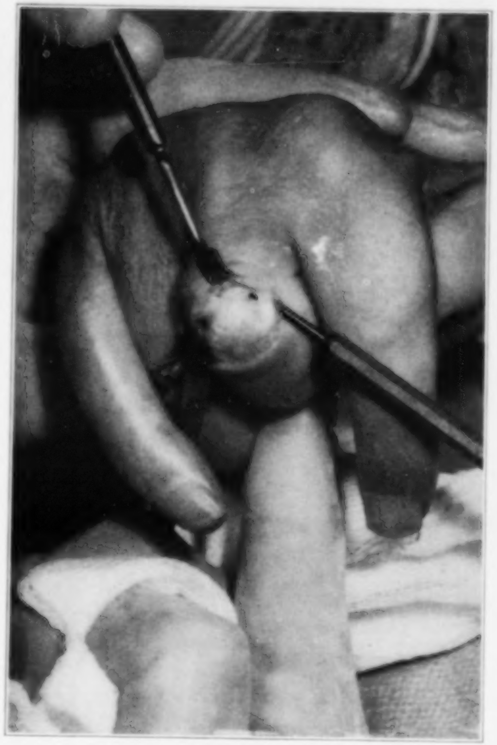

Fig. 15-B

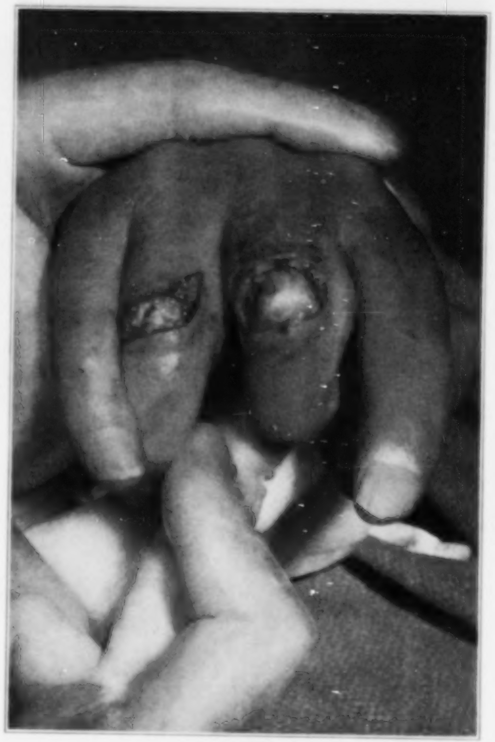

Fig. 15-C

Fig. 15-B: After the adherent lateral bands had been isolated and the metacarpophalangeal joint had been flexed, the distal interphalangeal joint could be flexed passively with ease.

Fig. 15-C: After the lateral bands had been sectioned, flexion at the proximal and distal interphalangeal joints could readily be done, even though the metacarpophalangeal joint was extended. Whether the lateral bands are sectioned or the muscle bellies are stripped from the metacarpals, the distal phalanx will still maintain a flexed position. When the lateral bands are sectioned proximally, there is still slight active extension of the middle interphalangeal joint, if the intrinsics have motor power.

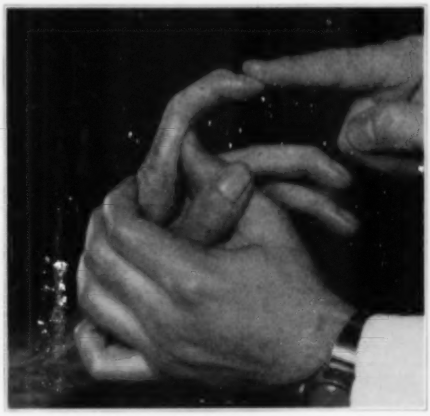

FIG. 16-A

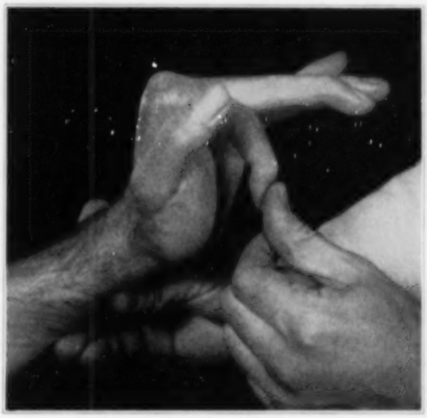

FIG. 16-B

Fig. 16-A: Local changes in the digits occur following roller injury. The lateral bands may become adherent on the dorsum of the proximal interphalangeal joints, even though the extensors are not contracted. In this hand, the test for contracture of the intrinsics was positive. Most of the change had taken place in the digit because of pathological changes in the joints and soft tissues.

Fig. 16-B: When the metacarpophalangeal joint was flexed, there was no increase in flexion of the interphalangeal joints. The extensor was not contracted or adherent on the dorsum of the metacarpal.

Fig. 16-C: An effort was made to reestablish function by releasing the adherent lateral bands. This was not successful. Fusion of the interphalangeal joints was done.

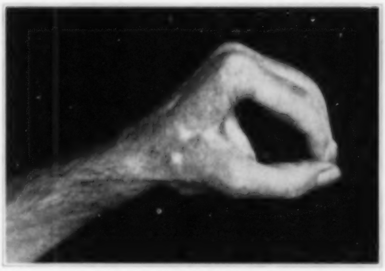

FIG. 16-C

proximal interphalangeal joint should be excised and arthrodesed. The cicatrix on the volar surface of the digit must be adequately removed and replaced by a split-thickness skin graft.

The "button-hole" deformity of the ring finger in this hand (Fig. 12-A) occurred, secondary to skin and tendon destruction over the proximal interphalangeal joint. The tight extension deformity of the distal phalanx was caused by contracture of the lateral

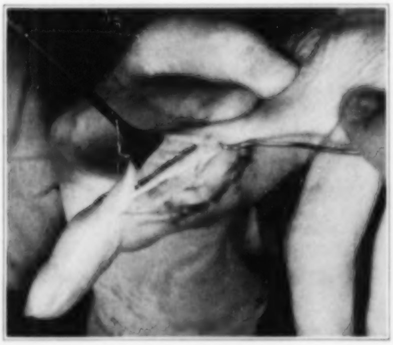

FIG. 17-A

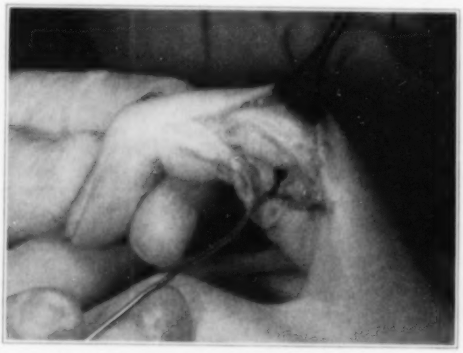

FIG. 17-B

Fig. 17-A: The lateral bands had migrated to the dorsum and had become contracted and adherent. Hyperextension at the proximal interphalangeal joint resulted in tension flexion of the distal joint.

Fig. 17-B: The lateral bands were allowed to slip over the side of the proximal interphalangeal joint. The synovial membrane and the volar ligaments, which were adherent, were released through a small buttonhole. Passive flexion improved, but the deformity recurred and fusion was necessary.

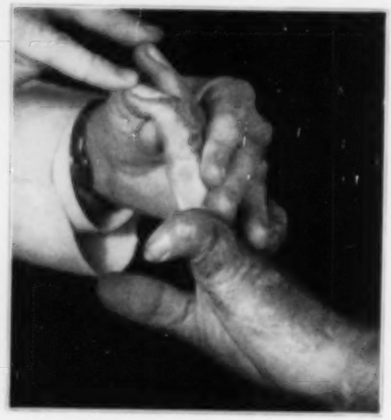

Fig. 18-A

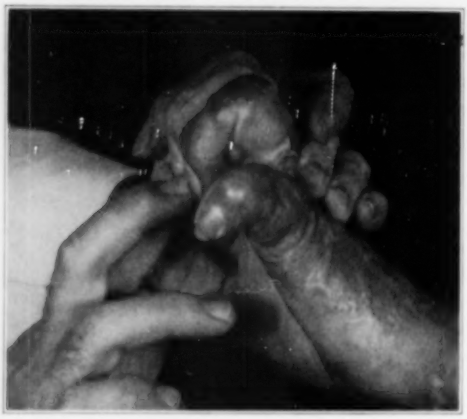

Fig. 18-B

Fig. 18-A: Contracture of the lateral bands in the digit alone could be proved by extending and stabilizing the proximal interphalangeal joints and by attempting to flex the distal joints. The distal phalanx of the ring finger in this hand could be flexed, because the lateral bands had been sectioned over the middle phalanx. The distal phalanx of the long finger could not be flexed because of dorsal contracture.

Fig. 18-B: With the proximal interphalangeal joints flexed, flexion of the same degree was present in the distal interphalangeal joints.

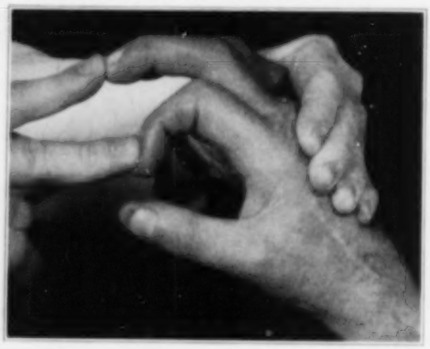

Fig. 19-A

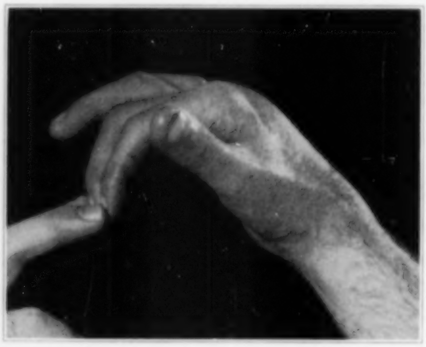

Fig. 19-B

Fig. 19-A: The test for contracted intrinsics was positive for the long finger but not for the index finger. Limited flexion in both digits suggested also that the extensor tendon itself was contracted.

Fig. 19-B: With the metacarpophalangeal joints flexed, there was less interphalangeal flexion of the index finger. This indicated that the extensor was contracted. That there was no increase in the flexion in the long finger indicated that contracture of the extensor mechanism, as well as that of the intrinsic mechanism, was preventing flexion. Release of both units was necessary before good flexion could be obtained.

bands after they had migrated or had adhered to the sides of the proximal interphalangeal joint. There was also shortening of the deep fascia, periosteum, and skin over the middle phalanx. Because of the friable skin, the partial ankylosis of the distal joint, and the extensive injury over the proximal joint, correction is not possible by the usual methods.

For treatment in this deformity, the lateral bands can be sectioned just distal to the proximal interphalangeal joint (Fig. 12-B) on the dorsal surface of the hand through a curved, slanting incision. A split-thickness skin graft can be used to fill in the defect. The resulting mallet finger will be permanent, but the flexion deformity at the proximal interphalangeal joint will improve. After the application of split-thickness skin grafts to the metacarpal region and over each distal interphalangeal joint, there is sufficient relaxation to eliminate blanching of the knuckles and to increase flexion at all the joints (Fig. 12-D).

If fixed changes occur at the base of the nail bed and in the distal interphalangeal joint, section of the lateral bands, followed by fusion of the distal joint, may be necessary in order to correct the "button-hole" deformity and to increase finger flexion. In certain burn cases, it is desirable to leave hyperextension of the distal interphalangeal joint and to make no effort to correct the "button-hole", if the patient's occupation would be hindered by a mallet finger.

"INTRINSIC-PLUS" (PILL-ROLLER) HAND

This condition can result from ischaemic contracture of the interossei and lumbricales and fascia, secondary to circulatory impairment from any cause. Severe trauma or rheumatoid arthritis can cause the deformity. In certain cases, the pathological condition may be in only the lateral bands. The typical appearance is one of flexion of the metacarpophalangeal joints, hyperextension of the proximal interphalangeal joints, and flexion of the distal interphalangeal joints (Fig. 13-A). This is the position which the hand assumes when the intrinsic muscles and fascia or the lateral bands become shortened and contracted. The axis of rotation of the metacarpophalangeal joints is toward the volar surface, and the tendons of the lumbricales and interossei are toward the volar side, pulling like a bowstring. In turn, the proximal interphalangeal joints are hyperextended by the strong pull of the intrinsics, and the lateral bands gradually migrate to the dorsum of the proximal joint. The volar capsule stretches and allows hyperextension, secondary to the primary joint change. The distal phalanx is flexed because there is no active extension from the lateral bands and because of hyperextension at the proximal interphalangeal joint. Advancement of the interossei through dorsal incisions (Fig. 13-B) allows some relaxation of the intrinsic mechanism and gives more flexion at the proximal interphalangeal joint (Fig. 13-C).

The clinical test for contracted intrinsics (Fig. 14-A) requires as much extension as possible at the metacarpophalangeal joints, followed by an attempt to flex the distal phalanges (Fig. 14-B). In this position, the lateral bands are toward the dorsum, and their tension is increased; they give limited flexion at the proximal and distal interphalangeal joints. Flexion of the metacarpophalangeal joints relaxes the lateral bands and allows flexion at the interphalangeal joints (Fig. 14-C). Under direct exposure (Fig. 15-A), the lateral bands can be isolated; and, with the digit toward extension, it is seen that the bands shift to the dorsum and become shortened. With flexion of the metacarpophalangeal joint and after dissecting the bands free from the aponeurosis (Fig. 15-B), the bands can be made to slip over the sides of the proximal interphalangeal joint. After the lateral bands have been severed (Fig. 15-C), there is increased flexion of the proximal interphalangeal joint, even with the metacarpophalangeal joint under forced extension. Also, the degree of active extension at the metacarpophalangeal joint increases. Partial extension of the middle phalanx, because of the intact central slip, is still possible in certain hands, but not in others.

In a hand which has fixed changes in the interphalangeal joints caused by trauma, the lateral bands may become adherent on the dorsum of this joint and may give the appearance of contracted intrinsics (Fig. 16-A). When the metacarpophalangeal joints are flexed (Fig. 16-B), the amount of motion at the interphalangeal joints does not increase. This indicates that any contracture is distal to the large joints. Exposure of a small joint (Fig. 17-A) shows the lateral bands to be on the dorsum; yet there is no limitation of extension at the metacarpophalangeal joint. An attempt was made to relocate the lateral bands, and to free the volar plate (Fig. 17-B), but even after adequate splinting and active motion, the deformity recurred. Before improvement in function could occur, fusion of the interphalangeal joints in a position of flexion was required.

Contracture of the lateral bands in the digit can be proved by the same kind of test as that used to indicate contracture of the intrinsic mechanism proximal to the metacarpophalangeal joint. The proximal phalangeal joint of the digit is hyperextended (Fig. 18-A), and an effort is made to flex the distal phalanx. Resistance is noted. Flexion of the proximal interphalangeal joint allows flexion of the finger tip (Fig. 18-B).

The index finger in Figure 19-A shows the metacarpophalangeal joint fully extended, but the proximal interphalangeal joint flexes adequately. This action implies that the intrinsic muscles are not contracted. The long finger in this same position does not have the same degree of flexion at the interphalangeal joints; this indicates that the intrinsics are shortened or that there is change in and around the finger joints. With the index metacarpophalangeal joint flexed (Fig. 19-B), the interphalangeal joints will not flex as much as previously because of the adherent dorsal tissues. The long finger appears the same in both tests; this indicates that the contracted extensor tissues have more effect on the motion of this digit than does the relaxation of the lateral bands.

CONCLUSIONS

1. Metacarpophalangeal joints in extreme hyperextension of long duration in conjunction with absent intrinsic muscles may be treated expediently by joint fusion.

2. Metacarpophalangeal joints with less severe hyperextension and with functioning intrinsic muscle mechanism can be improved by the adequate excision of collateral ligaments, freeing of all dorsal tissues, and stripping of the volar plate. The heavy deep dorsal fascia in particular must be excised.

3. When the intrinsic strength of the index finger is being restored in the absence of contractures, it is advisable to replace weak lumbrical and volar interosseus muscles, as well as a weak first dorsal interosseus. This strengthens volar abduction and gives a strong pinch.

4. If the dorsal hood is destroyed and the joint is affected, fibrous ankylosis or osseous fusion gives a desirable end result.

5. If the dorsal hood is intact and the extensor tendons are destroyed, it is desirable to correct the extension contracture by adequate excision of scar tissue and collateral ligaments, followed by the replacement of the extensor tendons.

6. In burns, a fixed "button-hole" deformity can be changed to a mallet deformity for better flexion,—that is, for a golfer, if other reconstructive measures cannot be done. In old burns, it is important occasionally to maintain a slight "button-hole" deformity if this position is consistent with a specific occupation,—that is, for a piano player.

7. Fusion of the middle or distal interphalangeal joints is a useful procedure for irreparable flexion or extension deformities.

8. The "intrinsic-plus" hand, due to contracture of the intrinsic muscle mechanism, can be improved by advancing the intrinsic muscles in the metacarpal region or by sectioning the lateral bands opposite the proximal interphalangeal joints.

9. It is necessary to differentiate a contracture of the intrinsic muscles and fascia, contracture of the lateral bands in the digit only, contracture of both the extensor mechanism and lateral bands, and changes in the digits due to pathological joint changes resulting in hyperextension.

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DISCUSSION

DR. S. BENJAMIN FOWLER, NASHVILLE, TENNESSEE: Dr. Goldner has given us a very scholarly presentation. He shows an understanding of the problems of the deformities and pathological changes of the extensor mechanism, which is really gratifying to see. His plan of treatment for these deformities which require multiple-stage procedures is good. His methods are sound and the results are excellent. I would not take issue with any part of his paper, but there are things I would like to emphasize.

In his paper he mentioned that a flexion deformity of the interphalangeal joint of the thumb is due to weakness of the extensor pollicis longus. A flexion deformity of the distal segment of the thumb will generally occur in a combined median-nerve and ulnar-nerve paralysis, because extension of the distal phalanx of the thumb is partially done by the adductor pollicis and the abductor pollicis brevis. They constitute as much as 50 per cent. of the power of extension of the distal segment of the thumb.

Another thing I would like to point out is that contracture of the intrinsic muscles of the hand, due to ischaemic fibrosis or to actual destruction of the muscle tissue, when mild in degree, is actually beneficial, because it will control hyperextension at the metacarpophalangeal joint and will act to extend the interphalangeal joint when the metacarpophalangeal joint is extended. Actually, it will take the place in some paralytic hands of a tendon transfer.

Correction of excessive contracture of the intrinsic muscles in the finger is best done by the direct lengthening of the extensor mechanism over the proximal phalanx, as indicated by Dr. Goldner. Stripping of the intrinsic muscles from the metacarpals seems to us to be an operation of considerably more magnitude. For some arthritic hands, which in certain cases show the same deformities as those resulting from ischaemia, Dr. Steindler has recommended excision of the metacarpal heads. In many cases this procedure results in a satisfactory correction of the deformity and in improvement in the function of the hand.

It is seldom, if ever, necessary to do a tendon transplantation to restore abduction to the little finger.

In reconstructive surgery of these severely deformed hands, we should not attempt to restore all function and motion, but in many instances we should attempt to simplify the mechanical unit by judicious use of arthrodeses of the wrist or metacarpophalangeal joints, and by amputation of a digit which is so badly injured that restoration, while possible, is really impractical.

DR. L. D. HOWARD, JR., SAN FRANCISCO, CALIFORNIA: Dr. Goldner has faced some very difficult hand problems and has shown a thorough understanding of the various principles involved in the reconstruction of such hands. The problems involved in any one of these hands he has shown are of great magnitude and the proper handling of them requires both experience and judgment. The principal contribution of the paper, as I see it, has been the use of selective tenotomies which convert one deformity into another, the latter being less disabling. Therefore, the procedure is established as worth while, when other reconstructive means are not applicable or are inadvisable. Tenotomies like arthrodeses become self-limited as to the number which can be performed, since both are destined to limit motion.

I trust Dr. Goldner will continue his interest in this type of work, and I think we can expect to hear more from him in the future.

DR. GOLDNER (closing): Dr. Fowler is correct when he points out that flexion deformity of the distal phalanx of the thumb is due, not only to weak extrinsic muscles, but also to weak intrinsics. The lateral bands in the thumb control the distal phalanx, just as they do in the fingers.

I should have explained why so much time and effort were expended in correcting the multiple contractures of the little fingers which resulted from a severe burn. The patient was a well known golfer. Preservation of his little fingers was essential. By undergoing resection of the interphalangeal joint and other procedures, he was able to retain the digits, change his grip to overlapping, and win his Ryder-cup match. The individual case must be considered. In a laboring man, amputation would have been done.

I wish to thank Dr. Howard for his remarks about sectioning the lateral bands over the middle phalanx for old button-hole deformities. It should be emphasized that fixed changes are present in the distal interphalangeal joint before this procedure is done. Otherwise treatment is directed toward the dorsum of the proximal interphalangeal joint or to the lateral bands opposite this joint.

PROBLEMS WITH TRAUMA TO THE HAND [*]

BY J. EDWARD FLYNN, M.D., BOSTON, MASSACHUSETTS

From the Hand Service, Boston City Hospital, and the Department of Surgery, Tufts Medical School, Boston

Two problems in regard to trauma to the hand are presented. First, we consider the circumstances under which one should perform primary reconstruction and primary closure and those under which one should perform delayed reconstruction and delayed closure in treating compound wounds of the hand. Second, we consider the manner in which one should treat injuries to the tendons of the flexor digitorum sublimis and the flexor digitorum profundus when the site of the injury is within a tight tendon sheath.

Many principles must be understood and many details must be followed for the proper treatment of compound wounds of the hand. A recognition of the type of the wound and the state of cleanliness is important.

TABLE I

CLASSIFICATION OF COMPOUND WOUNDS OF THE HAND [†]

- Incised wounds:
  - Clean (inside sheath or outside sheath)
  - Dirty (inside sheath or outside sheath)
- Crushed wounds:
  - Clean (inside sheath or outside sheath)
  - Dirty (inside sheath or outside sheath)
- Avulsed wounds:
  - Clean (inside sheath or outside sheath)
  - Dirty (inside sheath or outside sheath)
  - Specific types:
    - Involving finger tip:
      - No bone exposed
      - Bone exposed
    - Finger:
      - Flexor or extensor surface involved
    - Glove avulsion of fingers or hand:
      - Volar or dorsal aspect of hand
- Late wounds:
  - Clinically (redness, oedema, and smear shows cocci or increased leukocytes)
  - In time (incised, crushed, or avulsed)
- Septic wounds

[†] Reproduced by permission of J. B. Lippincott Company from *Annals of Surgery*, Vol. 135, No. 4, April 1952.

In Table I, compound wounds of the hand are classified according to the types encountered over a four-year period at the Boston City Hospital.

An accurate history is important in deciding upon the proper procedure. We are interested especially in the causative agent, the circumstances, the place, the first aid, and the time from injury to admission to the hospital.

On preliminary inspection, the location, extent, state of cleanliness, and type of wound are carefully noted. The wound is dressed and physical examination for bone, nerve, and tendon injury is performed, so that a clinical diagnosis is made before the patient is sent to the x-ray department or operating room.

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[*] Presented at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 25, 1952.

TABLE II

TREATMENT OF COMPOUND WOUNDS: THE EFFECT OF ANTIBIOTICS ON THE TIME FACTOR IN RESPECT TO TREATMENT OF INCISED WOUNDS *

	Wound Treatment	Tendon Treatment
Incised wounds (clean)	Primary suture if done within twenty-four hours or if there is no inflammation.	
Outside sheath		Primary suture if done within twenty-four hours.
Inside sheath		Primary suture if done within twelve hours.
Incised wounds (dirty)		
Débridement complete	Primary suture if done within twelve hours or if there is no inflammation.	Primary suture if done within eight hours.
Débridement incomplete	Delayed closure; vital structures covered.	No primary repair.

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Xylocaine, a brachial block anaesthesia, is used for extensive injuries which require three or more hours of operating. Many details must be followed in the preparation of the part for surgery. All surfaces of the upper extremity must be shaved from elbow to finger tips. This same area is scrubbed for ten to twenty minutes, pHisoderm and cotton gauze being used. The irrigation is best performed by means of an irrigation nozzle placed deep in the wound. Copious amounts of normal saline are used. For crushed and contaminated wounds, twenty liters of saline are often used. A sterile modified Bryant pan (Fig. 1) provides for a more sterile irrigation than the placing of the part on a board covered by a sterile sheet, which soon becomes wet and contaminated. The area about the wound is again prepared with pHisoderm and the operation is begun.

TABLE III

TREATMENT OF COMPOUND WOUNDS: THE EFFECT OF ANTIBIOTICS ON THE TIME FACTOR IN RESPECT TO TREATMENT OF AVULSED WOUNDS *

	Wound Treatment	Tendon Treatment
Avulsed wounds (clean)	Primary suture if done within twelve hours or if there is no inflammation.	
Outside sheath		Suture incised tendons within twelve hours; do not repair avulsed tendons.
Inside sheath		Suture incised tendons within eight hours; do not repair avulsed tendons.
Avulsed wounds (dirty)		
Débridement complete	Primary closure if done within twelve hours or if the wound shows no inflammation.	Suture lacerated tendons within six hours; do not repair avulsed tendons.
Débridement incomplete	Delayed closure; vital structures covered.	No primary repair.

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TABLE IV

TREATMENT OF COMPOUND WOUNDS: THE EFFECT OF ANTIBIOTICS ON THE TIME FACTOR IN RESPECT TO TREATMENT OF CRUSHED WOUNDS *

	Wound Treatment	Tendon Treatment
Crushed wounds (clean)	Primary suture if done within twelve hours or if there is no inflammation.	
Outside sheath		Suture incised tendons if done within twelve hours; do not repair crushed tendons.
Inside sheath		Suture incised tendons if done within six hours; do not repair crushed tendons.
Crushed wounds (dirty)		
Débridement complete	Primary closure if done within eight hours or if wound shows no inflammation.	Suture incised tendons if done within six hours; do not repair crushed tendons.
Débridement incomplete	Delayed closure; vital structures covered.	No primary repair.

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In a previous preliminary report [8], we estimated how much we believed antibiotics had increased the time factor for safely operating upon compound wounds of the hand.

Results in 618 patients with compound wounds of the hand, over a three-year period, have been reviewed. These results indicate that our estimate of the increase in the time one had from injury to operation is proper and is considerably longer than the six-hour limit of the pre-antibiotic era.

Tables II, III, and IV present, in summary, our estimate of how antibiotic therapy may increase the time in which primary reconstruction may be performed in different types of wounds. Indications for delayed reconstructions are also presented.

In our series, there were eighty-four patients with clean incised wounds involving tendons within sheaths in which primary tenorrhaphy was performed. These patients were operated upon from one to twelve hours after injury; eight patients were operated upon between the eleventh and twelfth hour after injury. There was no postoperative sepsis in any case.

There were 309 patients with clean incised wounds involving tendons without sheaths. These patients were operated upon from one to twenty-four hours after injury. There were five patients in whom postoperative sepsis

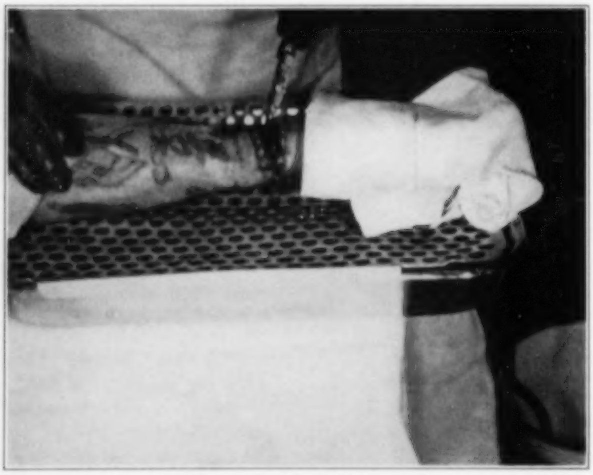

FIG. 1
Sterile pan for irrigation.

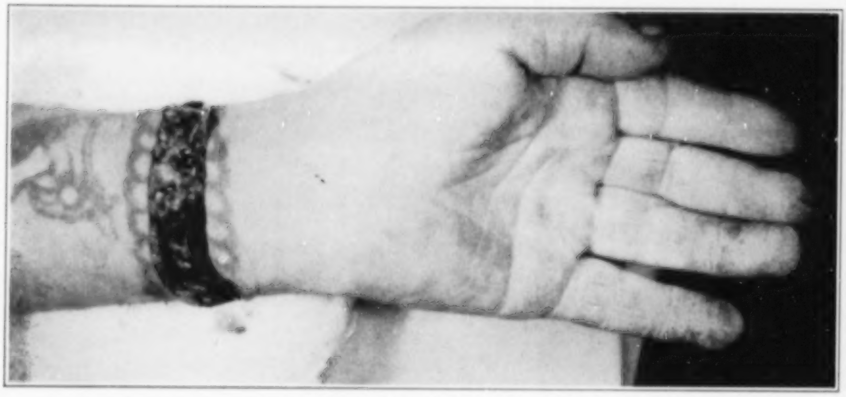

FIG. 2

Clean, incised compound wound of the wrist, with successful primary reconstruction and closure fourteen hours after injury.

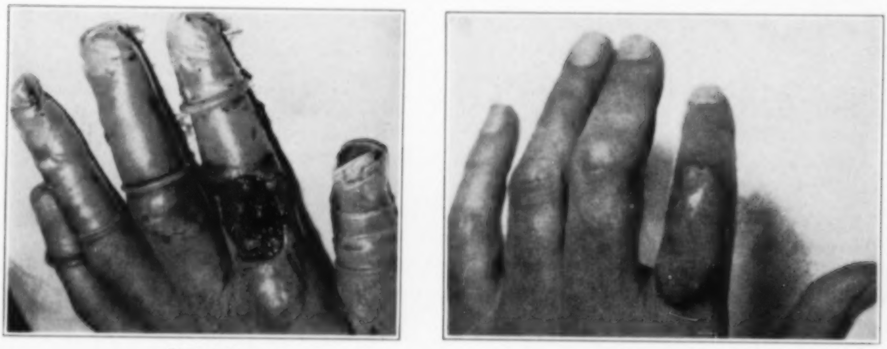

FIG. 3-A FIG. 3-B

Fig. 3-A: Avulsed wound of skin, tendon, bone cortex, and marrow.
Fig. 3-B: Generous primary pedicle grafting of avulsed wound facilitates later reconstruction.

occurred. All five patients had multiple tendon and nerve injuries; operation was performed within six hours in each case.

There were six patients with dirty incised wounds, involving tendons within sheaths, in which débridement was complete and primary tenorrhaphy was performed. These patients were operated upon from one to four hours after injury. There was no postoperative sepsis.

There were thirty-six patients with dirty incised wounds, involving tendons without tendon sheaths, in which débridement was complete and primary repair of tendons was performed. These patients were operated upon from one to eight hours after injury. There was no sepsis after operation.

Figure 2 shows a clean incised wound of the wrist involving all tendons, the median and ulnar nerves, and the radial and ulnar arteries, in which primary reconstruction was performed fourteen hours after injury, without sepsis.

In our series, there were eighty-nine patients with clean avulsed wounds involving tendons without sheaths in whom primary closure of the wound or primary tenorrhaphy was performed. Primary tenorrhaphy was performed from one to seven hours after the injury in patients with sharply incised tendons. There was no postoperative sepsis. There were four patients with clean avulsed wounds involving incised tendons within sheaths which were repaired within six hours of injury, without postoperative sepsis.

TABLE V

RESULTS IN REPAIR OF TENDON INJURIES *

Tendon	Cases	Good		Fair		Poor	
	(No.)	*(No.)*	*(Per cent.)*	*(No.)*	*(Per cent.)*	*(No.)*	*(Per cent.)*
Flexor carpi radialis	26	26	100				
Flexor carpi ulnaris	22	22	100				
Extensor carpi ulnaris	5	5	100				
Extensor carpi radialis	5	5	100				
Abductor pollicis longus	5	4	80	1	20		
Extensor pollicis longus	13	10	77	3	23		
Extensors of fingers in forearm or wrist	7	5	71	2	29		
Flexors of fingers in forearm or wrist	104	60	57	28	27	16	16
Extensors of fingers on dorsum of hand	37	21	57	9	28	7	15
Flexor pollicis longus	29	16	55	7	24	6	21
Flexors in palm	19	9	47	4	22	6	31
Extensors within fingers	40	19	48	8	20	13	32
Flexors within fingers (sheaths)	89	14	16	29	33	46	51
Total number of tendons	401						

* Over a two-year period there were 478 tendon lacerations in 226 patients. Because lacerations of the tendons of the thenar and hypothenar groups of muscles are not included in this table, the total number of tendons is 401.

There were twenty-eight patients with dirty avulsed wounds involving tendons without sheaths, in which débridement was complete and in which primary closure with primary tenorrhaphy of incised tendons were performed. These patients were operated upon from one to five hours after injury. There was no postoperative sepsis.

There were three patients with dirty avulsed wounds with sharply incised tendons within sheaths. Adequate débridement, primary tenorrhaphy, and closure of wound were performed in all within three hours of injury (Figs. 3-A and 3-B). There was no postoperative sepsis.

There were twenty-six patients with clean crushed wounds involving tendons without sheaths. Primary closure with primary tenorrhaphy of incised tendons was performed in these patients within one to six hours from the time of injury, with no subsequent sepsis.

In our series there were two patients with clean crushed wounds which involved tendons within sheaths. Both were operated upon within six hours, with subsequent primary healing.

There were thirty patients with dirty crushed wounds involving tendons without sheaths, in which débridement was complete. Primary closure, with primary tenorrhaphy of the incised tendons, was performed in these within one to seven hours from the time of injury. There was no postoperative sepsis. One patient with a dirty crushed wound involving a tendon within a sheath was operated upon within four hours with subsequent primary healing (Figs. 4-A and 4-B).

In reviewing 618 patients with compound wounds of the hand, over a three-year period, we found only five patients in whom postoperative sepsis developed.

TENDON INJURIES

In the second problem, we consider how one should treat lacerations of both flexor digitorum sublimis and flexor digitorum profundus tendons, when the injury is between the distal transverse crease of the palm and the middle of the middle phalanx. The poorest results obtained were in the repair of the flexor tendons in this region, where the tendons are enclosed in a narrow firm sheath. After the suturing of a tendon within this sheath, the swelling of repair is not permitted by the enclosing firm tunnel. The blood supply is

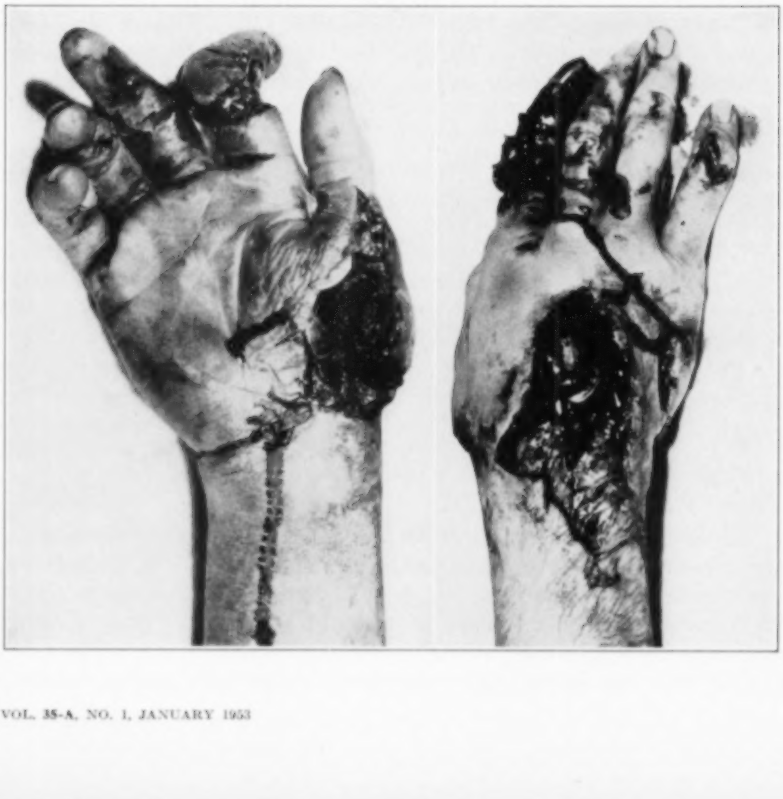

Fig. 4-A

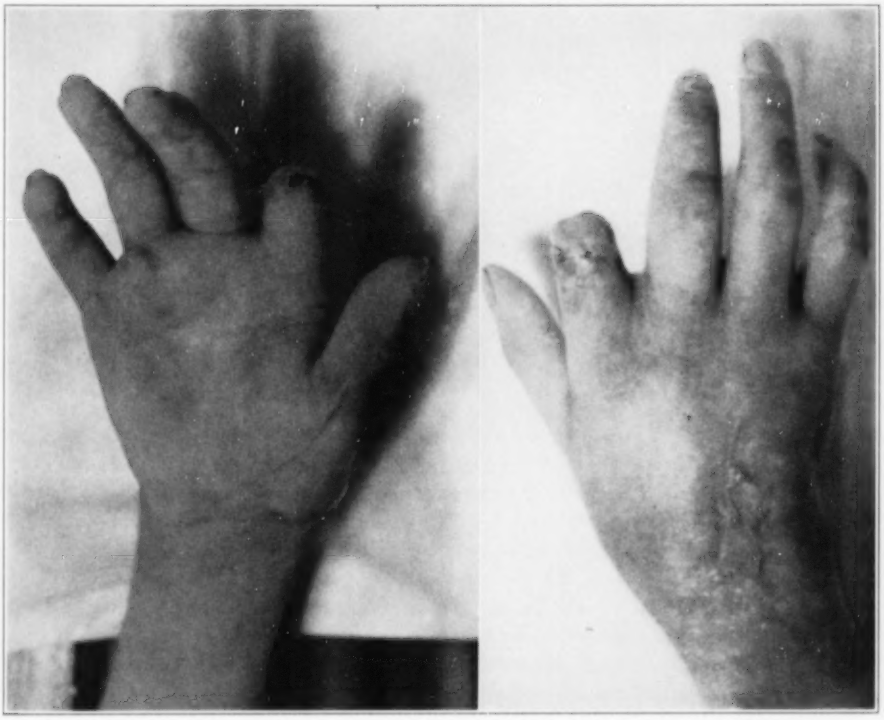

Fig. 4-B

Fig. 4-A: Anterior and posterior views of severely crushed, dirty, compound wounds, treated eight hours after injury.

Fig. 4-B: Crushed wounds after proper irrigation, débridement, and skin coverage healed *per primam*, facilitating later reconstruction.

TABLE VI

SUTURE TECHNIQUE AND RESULTS IN FLEXOR-TENDON INJURIES WITHIN FINGER SHEATHS

Technique	Cases (*No.*)	Results					
		Good		Fair		Poor	
		(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)
Silk	37	5	14	14	38	18	48
Wire (Bunnell)	40	7	18	11	27	22	55
Suture at a distance with silk and wire	12	2	17	4	33	6	50
Total	89	14	16	29	33	46	51

compressed and the tendon becomes necrotic. Resolution of tunnel contents results in a cicatrical mass. To forestall such a mishap in primary tenorrhaphy, the fascial tunnel should be incised its entire length to decompress and to maintain vascularity of the tendon during the stage of healing.

When the sublimis and profundus tendons are cut within a sheath, both tendons cannot be sutured with success, as the sutured sites will become adherent and will not slip. The ultimate loss of function is greater than if one tendon had been sutured. Therefore the sublimis tendon is removed from the finger and only the profundus is sutured.

However, even with incision of the tendon sheath and the sacrifice of the flexor digitorum sublimis tendon, the results with primary tenorrhaphy for tendon lacerations within tight sheaths are still notoriously poor.

Incidence of Tendon Injuries

Over a two-year period on the Hand Service of the Boston City Hospital, there were 478 tendon lacerations in 226 patients. The injuries involved the flexor tendons in 346 cases and the extensor tendons in 132—a ratio of about three to one.

Classification of Results with Flexor-Tendon Injuries

The results, following reconstruction of flexor tendons within a sheath, may be classified on the basis of the ability to touch the injured finger tip to the distal transverse crease of the palm on flexion.

An optimum result is obtained when active flexion at each interphalangeal joint is 90 degrees or the equivalent. On flexion, one is able to touch with the tip of the finger the distal transverse crease of the palm. A fair result is one in which active flexion at each interphalangeal joint is 45 degrees or the equivalent. On active flexion, the tip of the finger should come to within one and one-half inches of the palm. A poor result is one in which active flexion at each interphalangeal joint is less than 45 degrees or the equivalent; on active flexion one is not able to bring the tip of the finger to within one and one-half inches of the palm.

Results with Tendon Injuries

Generally, the results following repair of flexor or extensor tendons of the wrist are excellent, and the results following repair of flexor or extensor tendons of the fingers in the forearm, wrist, and hand are fair. The results following primary reconstruction after injury to both flexor tendons, when the site of injury is between the distal transverse crease of the palm and the distal volar crease of the finger, are universally poor (Table V). In our series, there were eighty-nine cases with injury to both flexor tendons within a

TABLE VII

COMPARISON OF THE RESULTS OF PRIMARY TENDON-SUTURE WITH TENDON-GRAFTING (BOYES)

Technique	Cases (*No.*)	Results		
		Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Primary suture	89	16	33	51
Tendon grafting:				
Good conditions	27	75		

TABLE VIII

RESULTS OF PRIMARY TENDON-GRAFTING FOR INJURY TO FLEXOR DIGITORUM SUBLIMIS AND FLEXOR DIGITORUM PROFUNDUS TENDONS WITHIN SHEATHS

Cases (*No.*)	Results					
	Good		Fair		Poor	
	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)
11	6	55	3	27	2	18

tendon sheath. In our series, the results were: 16 per cent., *good;* 33 per cent., *fair;* and 51 per cent., *poor* (Table VI).

Comparative Results with Different Techniques

Tendons were repaired by means of the silk technique, the pull-out wire technique, and the suture-at-a-distance technique. The results were about the same with whatever technique was used. This fact seems to indicate that better results will not be obtained with a variation of tendon-suturing, but with some radically different procedure. Table VI shows the results obtained with the different suturing techniques.

Results with Delayed Flexor-Tendon Grafts

Boyes classified cases in which delayed flexor-tendon-grafting was performed as follows: good, cicatrix, joint damage, nerve damage, and multiple damage. There were 138 cases of tendon-grafting in Boyes' series with twenty-seven cases classified as good. In 25 per cent. of these, the patients were able to touch the distal palmar crease with the pulp of the finger, and in 50 per cent. of these, the patients were able to bring the pulp of the finger to within one-half inch of the distal crease of the palm.

Comparison of Primary Tendon-Suturing with Tendon-Grafting

In view of our present poor results with primary reconstruction of tendons within sheaths, one would gladly accept a procedure which would allow 50 per cent. of the patients such active flexion that they could bring the finger pulp within one-half inch of the palm.

We believe that, with the proper selection of cases, primary tendon-grafting should be attempted. The wound should be clean and incised, with no element of avulsion or crushing. Both sublimis and profundus tendons must be divided between the distal transverse crease of the palm and the distal volar crease of a finger. Table VII is a comparison of our results in primary tenorrhaphy with Boyes' results in delayed tendon-grafting.

COMMENT

One must select carefully the cases in which a primary tendon-grafting should be performed for fresh injuries to both flexor tendons within a sheath. The wound must be clean and incised. In the presence of any crushing or avulsion of the wound, it is better simply to close the wound and to perform tendon-grafting later when all reaction has subsided.

In this preliminary report of eleven cases in which primary tendon-grafting was done, six of the patients were, on flexion, able to touch the pulp of the finger to the distal transverse crease of the palm; three were able to bring the pulp of the finger to within one-half inch of touching the palm; and two failed to bring the pulp of the finger to within one and one-half inches of the palm (Table VIII).

The value of primary tendon-grafting for injury to the flexor digitorum sublimis and the flexor digitorum profundus tendons within a sheath cannot be definitely stated until after a series of at least fifty cases has been evaluated.

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DISCUSSION

DR. SUMNER L. KOCH, CHICAGO, ILLINOIS: I would not completely agree with the prolonged period of time in which Dr. Flynn has suggested that the primary repair of tendon injuries can still be safely accomplished. We are not convinced that the use of antibiotics is as complete a safeguard as has been suggested. There are many bacteria not susceptible to the antibiotics commonly in use, and bacteria are becoming less susceptible with the increasing and widespread use of antibiotics.

Dr. Flynn has rightly distinguished between clean-cut tendons and crushed tendons. I wonder, however, if there are not cases in which the crushed portion of the tendon might be excised and the clean-cut tendon ends united immediately after the injury.

When flexor tendons have been divided within the tendon sheath by a clean-cut incision, it is possible to repair the tendon within the digital sheath and to secure a good result, if one can see the patient immediately after the injury. One does not need heavy suture material to hold the tendon ends in apposition. A simple

(*Continued on page 171*)

MODIFIED INTRAMEDULLARY NAILING IN RECENT GUNSHOT FRACTURES OF THE FEMORAL SHAFT *

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AND COLONEL VINNIE H. JEFFRESS, *Medical Corps, United States Army*
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There is reason to believe that intramedullary fixation of fractures of the long bones was used in some fashion by the ancients. In the modern literature its use was illustrated by Lambotte in 1913 in his textbook on the operative treatment of fractures. Its application to the treatment of gunshot fractures of the femur was reported in 1918 by Hey Groves. The more recent use of the method by Küntscher [8, 9] and his collaborators and by L. V. Rush and H. L. Rush has been followed by widespread adoption of the procedure in special types of fractures and under optimum surgical conditions. When properly applied, the method is now recognized as an outstanding contribution to fracture management, especially in fractures of the middle three fifths of the femoral shaft. The material dealt with in this paper is confined to the treatment of fractures in this anatomical area.

Ordinarily the procedure of intramedullary femoral nailing is performed by open reduction; the experiences reported have been entirely with this method. Usually the procedure is considered only in patients with closed fractures or in open fractures after the wounds have well healed. A natural variation of the method, however, is to use it in certain open fractures, either at the time of débridement with primary skin closure or at the time when a delayed or secondary closure is performed. It was a logical step to consider its use during World War II in connection with the problems of management of the large numbers of gunshot fractures of the femoral shaft.

The work of Küntscher, Heim, Böhler [1, 2], and others demonstrated that intramedullary nailing has a definite place in the treatment of selected gunshot fractures. In addition to its use in patients whose gunshot wounds had completely healed without infection, the method was used in the original treatment of relatively clean wounds either at the time of primary débridement or in association with delayed wound closure. Later its use was advocated even in patients with definite wound infection and in the face of severe toxicity and general debility. In the latter cases, the observers, notably Heim and Haebler, reported that the fixation of the fracture by the intramedullary nail and the institution of adequate drainage with the wounds left wide open resulted in immediate improvement in the patient's general condition, wound healing without the spreading of infection, bone union in the great majority of cases, and no significant operative complications.

INDICATIONS

It is a common observation that most gunshot fractures of the femoral shaft will heal under conservative treatment by traction-suspension. Brav and Fitts noted bone healing in seventy-one of a series of seventy-four fractures (96 per cent.) treated in the China-Burma area during World War II. Soto-Hall and Horwitz, in a similar study of 100 gunshot fractures of the femur treated by traction-suspension, noted only thirteen cases of non-union. However, it is also a general experience that patients so treated have an extended period of recumbency, prolonged convalescence, and in a large percentage of cases, residual disability due principally to knee stiffness. It has been noted, furthermore, that when there are complicating factors such as severe wound infection, marked loss of soft tissue or bone, difficulty in reduction and fixation by conservative methods, or associated injuries requiring frequent movement of the patient, the results obtained are most discouraging. Maintaining the morale of these patients during prolonged recumbency is often a serious problem. Under these conditions the rate of non-union is greater, the knee restriction is more marked, the general condition of the patient is often difficult to support, and there is the danger of widespread soft-tissue and bone infection. Many cases require precarious secondary bone-grafting procedures and amputation is a not infrequent termination after months or years. Renal lithiasis, decubiti, and amyloid disease are other complicating factors. The economic and sociological stress can often be disastrous.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 30, 1952.

In our management of severely infected fractures of the femoral shaft in Korean casualties, we turned to intramedullary nailing with the feeling that, in spite of the obvious risks, there was much to be gained when the patients were expected to have a stormy course and a poor prognosis by ordinary conservative management. Our experience has been with only eight patients; the treatment was undertaken in the hope that this small group might provide information for the future management of many similar patients. All of our patients have been followed for a minimal period of two years from the time of surgery.

ANALYSIS OF PRESENT SERIES

Early Management

All of our patients were treated in an Army general hospital and all were young adult males. One patient presented a gunshot fracture of the femur sustained in a civilian accident; he had continued purulent drainage and non-union after fourteen weeks of conservative treatment. The remaining seven patients were Korean casualties whom we treated between four and thirteen weeks after injury, the average time interval between injury and treatment being 7.3 weeks. All had been treated by débridement and immobilization but presented severe residual wound infection with some loss of bone. It was apparent to us that these patients faced long periods of conservative treatment with recumbency, repeated sequestrectomies, and the possibility of multiple complications, including spreading infection, non-union, and even amputation.

Aside from temporary immobilization of these patients, our first efforts were directed toward improvement in general nutrition. These patients were all febrile and toxic, but none was in critical condition. Rest, both local and general, and supportive treatment resulted in gradual improvement, but the wounds continued to drain and roentgenograms usually revealed evidence of definite sequestra. Wound cultures showed a variety of organisms, but all had one factor in common — all were resistant to penicillin which these patients had been receiving since their injuries.

No patient was taken to surgery until his general condition was considered satisfactory for a major operative procedure. Blood was available at surgery for all patients. Preoperative scanograms were made to determine the approximate length of the cloverleaf intramedullary nail which would be required. Correction was made for bone loss already sustained and for the estimated additional amount which might be removed at operation. Since this was only approximate, nails of various lengths and diameters were always available. There was full assurance that the operative facilities, including both personnel and specialized equipment, were adequate for any surgical eventuality.

Operative Procedure

There was some variation in the operative approach to the fracture site. All fractures were exposed from the posterolateral aspect; this is essential because of the necessity for posterior drainage. In some instances there was a wound which could be enlarged for adequate exposure. If the wounds were located medially or anteriorly, a separate posterolateral incision was made. The patients were strapped to the operating table on the side opposite the fracture, and the injured extremity was left free for manipulation. After exposure of the fracture site a meticulous débridement was performed, with minimal periosteal stripping but with removal of all accessible foreign material, all necrotic soft tissue, and all bone which was either completely separated or which showed definite evidence of loss of blood supply. This entailed considerable judgment, especially in removal of bone. All small questionable fragments were removed, but larger fragments were allowed to remain if their loss would give rise to significant shortening. Any error that was made was on the side of bone removal; this is demonstrated by the rather high average of residual bone shortening in our patients (1.8 inches).

After thorough débridement and wound irrigation, the remaining fracture ends were gently freshened and the nail diameter proper for adequate immobilization was determined by actual trial with the nails on hand. The remainder of the procedure was the same as in the routine femoral nailing operation. The canals were reamed above and below the fracture site, so that the nail could be well accommodated. The guide emerged through the skin above the trochanter and a generous skin incision was made at this point. The hollow drill was then used to make an opening into the trochanter and the nail was inserted over the guide. After the nail had been driven half the distance to the fracture site, the guide was removed. Upon the appearance of the nail at the site of fracture, it was permitted to extend about three-quarters of an inch and was then threaded by gentle manipulation into the canal of the largest distal fragment. Care was taken to prevent abnormal rotation of the lower fragment and, as the nail was driven into the lower fragment, distraction was avoided. A roentgenographic check was made of the fracture site and of the knee before the nail was driven completely into the lower fragment, only the eye portion remaining exposed above the trochanter for subsequent removal. All of the usual precautions and safeguards to prevent nail impaction and other operative complications were maintained. No supplementary metal wire or screws were used for fixation; no bone grafts were applied; and *all wounds were left wide open* for drainage.

Postoperative Care

All patients were placed in a suspension apparatus without traction. Minimal hip and knee flexion was maintained, but the limb was kept slightly above the horizontal level to prevent oedema. All patients were given penicillin postoperatively until the bacterial sensitivity to antibiotics was noted. Frequent changes of antibiotics were necessary as subsequent wound cultures revealed differences in bacterial flora. Postoperative drainage was usually profuse, and there was marked dehydration requiring liberal use of blood and fluid. The patients were comparatively comfortable as a result of wound and fracture stabilization, but there was almost invariably a marked temperature reaction for several days. At the end of this period there was a gradual subsidence of fever, but low-grade elevation persisted in some cases for many weeks. In five cases there were periods of retention of wound products or of sequestra requiring repeated surgical drainage and sequestrectomy. At first, drainage was effected by insertion of rubber tubing into the posterior wound and of vaselin gauze wicks into the other wound areas. At the end of a few days to a week the tubing was replaced with vaselin gauze.

Wound healing varied in rapidity but generally progressed in a most encouraging manner. Only one case was considered appropriate for split-thickness skin coverage and in this case it was only partly successful, with prolonged persistence of a draining sinus. In the remainder the wounds rapidly became epithelialized, but small sinuses persisted, in some cases for many months. Three patients continued to show slight intermittent drainage when last seen, after two years.

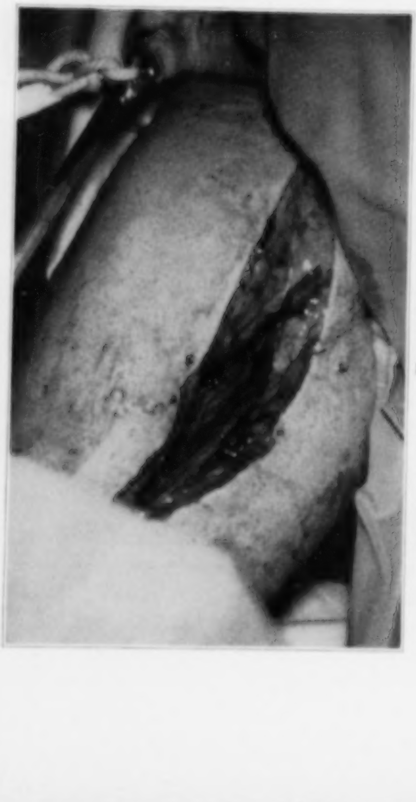

FIG. 1-A
Showing posterolateral thigh wound one week after operation.

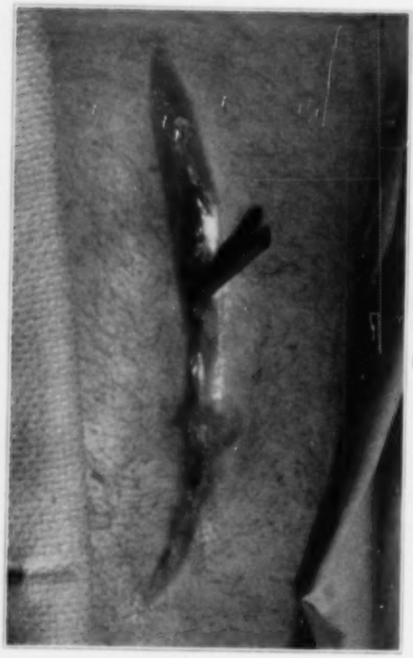

FIG. 1-B
Five weeks after operation.

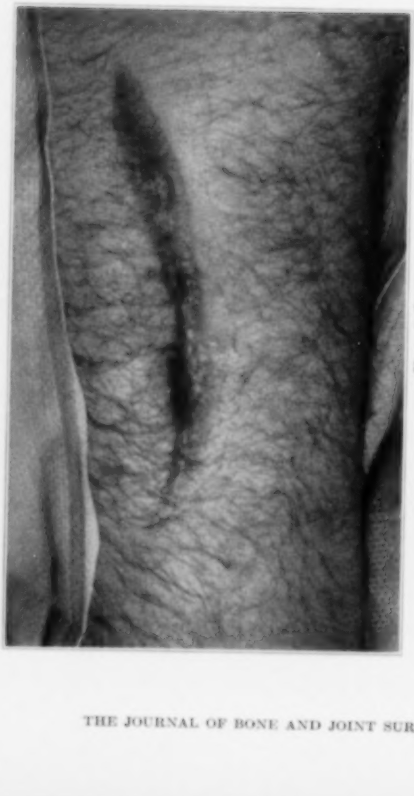

FIG. 1-C
Thirteen weeks after operation.

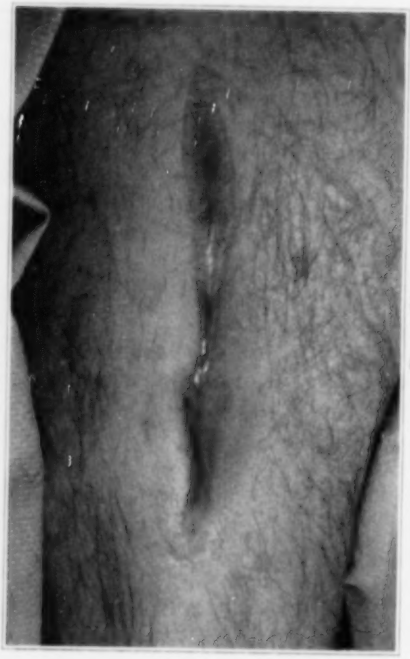

FIG. 1-D
Nineteen weeks after operation the wound had healed.

(Figs. 1-A to 1-D from Photographic Laboratory, Letterman General Hospital, San Francisco, California.)

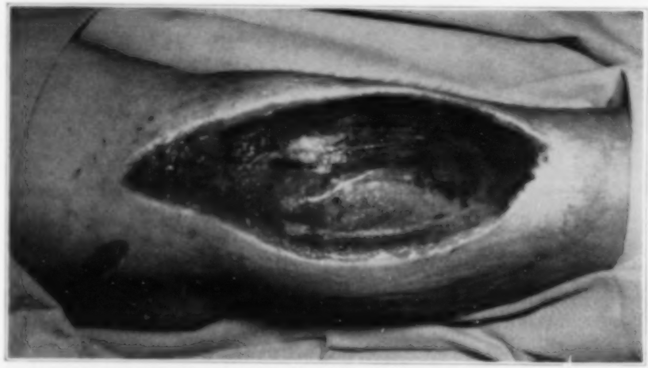

FIG. 2-A
Showing posterolateral thigh wound three weeks after operation.

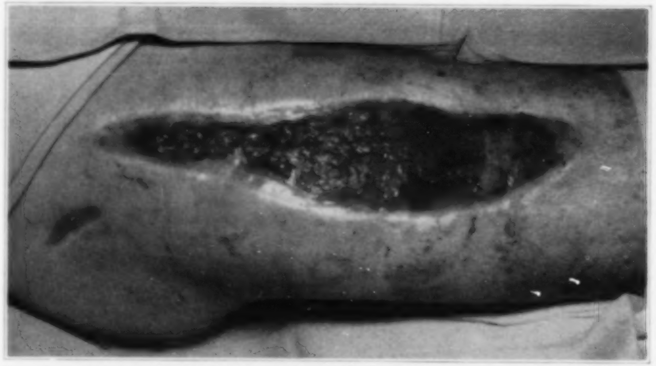

FIG. 2-B
Seven weeks after operation.

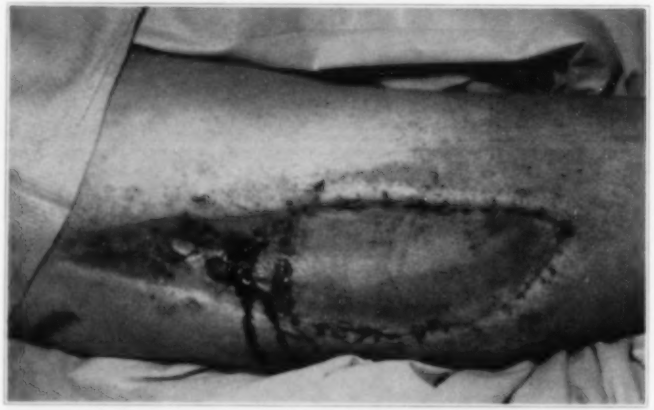

FIG. 2-C

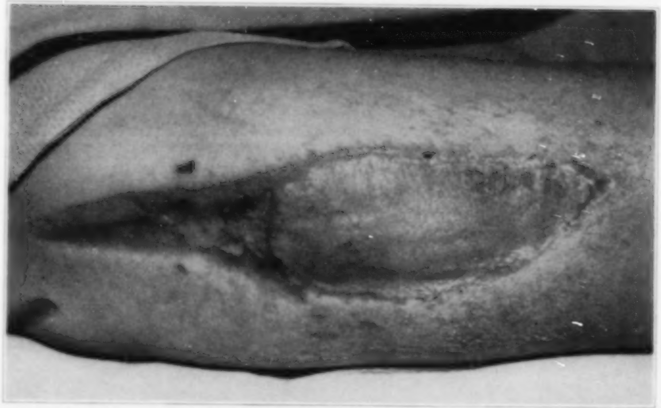

FIG. 2-D

Fig. 2-C: Twelve weeks after operation and two weeks after application of a split-thickness skin graft.
Fig. 2-D: Fifteen weeks after operation a small draining sinus remained. In this patient slight drainage persisted at intervals for a two-year period.

(Figs 2-A to 2-D from Photographic Laboratory, Letterman General Hospital, San Francisco, California.)

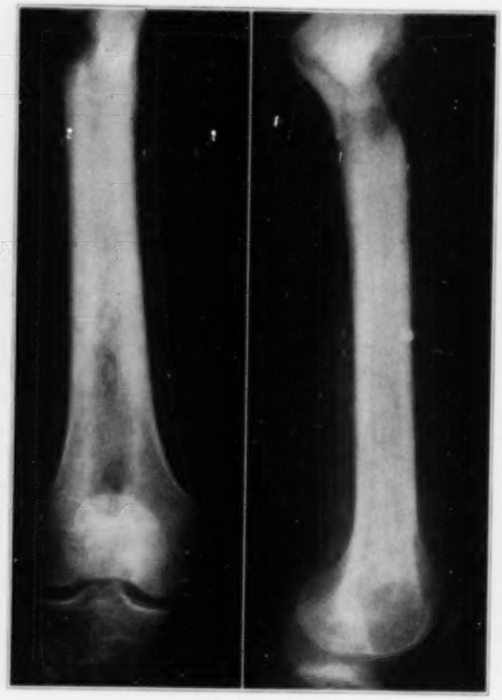

FIG. 3-A

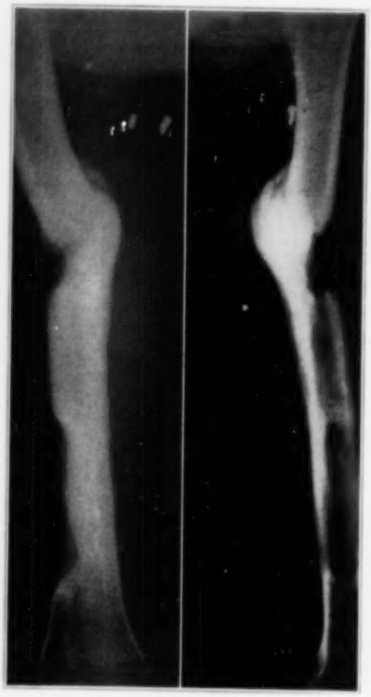

FIG. 3-B

Fig. 3-A: Showing focus of osteomyelitis at distal end of nail tract nine months after operation.

Fig. 3-B: Seventeen months after operation there was bone healing at the fracture site and infection had been controlled by drainage and saucerization. When the patient was last seen, the wound still presented slight intermittent drainage. (Figs. 3-A and 3-B from Photographic Laboratory, Letterman General Hospital, San Francisco, California.)

In the early postoperative stages, various solutions were used for wound irrigation in order to facilitate drainage and stimulate healing. These included antibiotic, proteolytic, and oxidizing solutions. None was considered superior to the others in any way. It is believed that the gentle mechanical flushing of the sinuses was the only local treatment required besides the maintenance of drainage.

Our policy as to the period of recumbency varied with the individual patient and the postoperative reaction, but it was possible for all patients to be out of bed in three to four weeks. The beneficial effect of this procedure on morale was obvious to all observers, and there was no noticeable interference with the progress of wound healing. Frequently there was temporary return to bed-patient status because of the necessity for surgical drainage or sequestrectomy. It was a uniform observation that the fractures were well immobilized by the nails and that there was no significant pain on motion of the extremity or on change of position from bed to chair.

Quadriceps exercises were given routinely as soon as patients had recovered from the surgical procedures. Knee motion was encouraged as early as one week postoperatively, an overhead pulley apparatus usually being installed. This part of the postoperative management often was not too well tolerated, because of discomfort at the wound site, and had to be curtailed as indicated. An effort was made to make these patients ambulatory with crutches at the earliest possible date after insertion of the nail. This required a somewhat longer period of bed rest than was required in ordinary cases of femoral nailing. However, ambulation was possible in all cases between six and eight weeks, with an average of 6.5 weeks. All initial weight-bearing was assisted by the physical therapist until patients could manage alone. There were several patients whose walking did not progress favorably either because of wound discomfort or lack of confidence, but none objected to ambulation and all were comfortable in wheel chairs. Braces were not used for support before nail removal, except in one patient who presented movement at the fracture site at sequestrectomy performed three months after the nailing procedure. The patients quickly sensed their advantage over other battle casualties who were being treated by traction-suspension; the effect on morale and general well-being cannot be overemphasized.

In addition to assistance with the recovering of knee function and strength of the involved extremity, the physical therapist was of great help in the avoidance of faulty gait habits and in general physical rehabilitation. Heel and sole lifts were required in most of the patients and, when these were of any significant amount (in one case it was two inches), they added to the problems of rehabilitation and the recovery of a satisfactory gait.

COMPLICATIONS

In this group of cases we noted no significant increase in soft-tissue infection. There was, on the contrary, rapid subsidence of local wound infection as a result of immobilization and drainage (Figs. 1-A to 2-D). When drainage became inadequate or when sequestration occurred, surgical correction was performed as indicated, but there was not the slightest evidence of increased soft-tissue involvement as a result of the nailing procedure itself. This was undoubtedly due to the adequacy of fixation and drainage and the use of blood and antibiotics.

Bone infection occurred in one patient, eight months after insertion of the nail and two months after its removal. This patient sustained a refracture after removal of the nail; during his immobilization in a plaster spica there was temperature elevation and a soft-tissue abscess developed in the lower portion of the thigh. Roentgenograms revealed a definite area of osteomyelitis (Fig. 3-A) in the lower portion of the femur along the tract of the nail. After preliminary evacuation of the soft-tissue abscess, a secondary saucerization of the involved bone was performed. This resulted in healing of the wound in a period of three months, and bone union proceeded without further difficulty (Fig. 3-B).

EVALUATION OF END RESULTS

All patients made a remarkable recovery from their operations and their general improvement was rapid. Fracture healing progressed rapidly in these severely infected wounds (Figs. 4-A to 4-D). No evidence of retardation of the healing process because of the intramedullary fixation was noted. At the end of the two-year follow-up period all patients were in excellent health and were ambulatory without any type of support for their femoral injuries even though fibrous union was present in one.

Associated Injuries

Two patients had associated sciatic-nerve injuries. One of these spontaneously recovered almost complete function of the extremity and never required support because of the rapid nerve regeneration. The other patient had partial recovery of sensation when last seen but still required the use of a wire drop-foot splint. Exploration of the nerve was necessarily postponed for twelve months because of persistent drainage; after healing the neurosurgeon advised against operation because of the prolonged delay. The patient refused the procedure of foot stabilization.

Wound Healing

Three patients still had slight intermittent drainage from the fracture site when

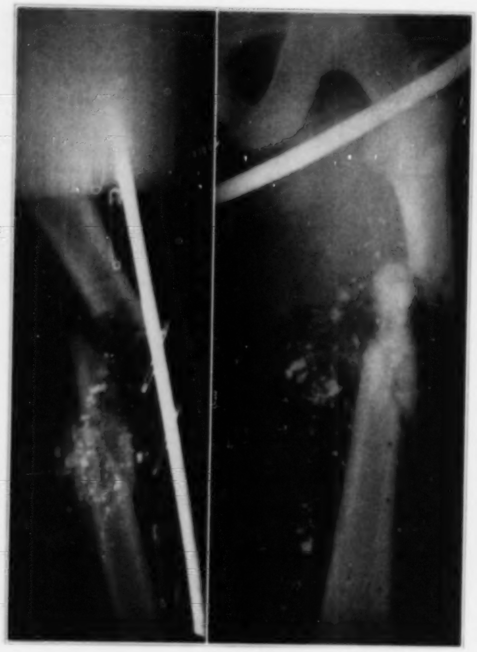

FIG. 4-A

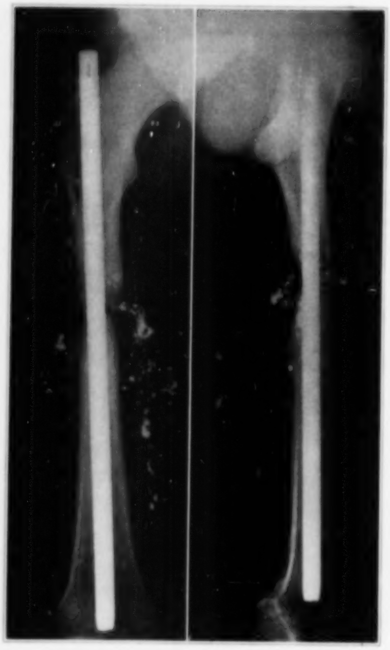

FIG. 4-B

Fig. 4-A: Preoperative lateral and anteroposterior roentgenograms.
Fig. 4-B: Roentgenograms made four weeks after operation.

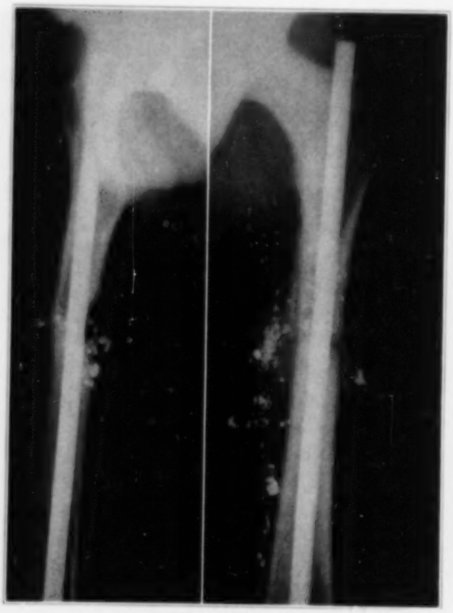

FIG. 4-C

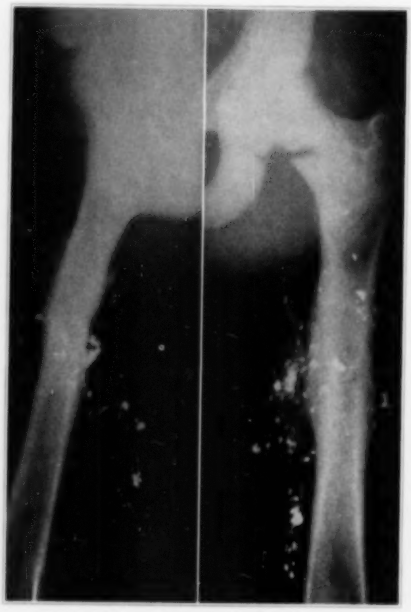

FIG. 4-D

Fig. 4-C: Eight weeks after operation bone union was well advanced.

Fig. 4-D: Six months after operation the nail was removed and there was solid bone union. (Figs. 4-A to 4-D from Photographic Laboratory, Letterman General Hospital, San Francisco, California.)

seen after two years. In all of these the fractures have united solidly and their activities are unrestricted. The average time of wound healing in this group of patients was thirty weeks. The shortest time of healing was six weeks and the longest sixty-eight weeks.

Bone Healing

There was satisfactory bone healing in all except one patient, who had a strong fibrous union but whose roentgenograms were typical of non-union of bone (Figs. 5-A to 5-C). The time of satisfactory bone union as noted on the roentgenogram varied between twelve weeks and fifty-two weeks, the average being 26.6 weeks.

Knee Function

There was slight limitation (5 degrees) of knee extension in two patients. In only one case was there recovery of less than 45 degrees of knee flexion. Four patients were able to flex their knees between 45 and 90 degrees and three had flexion beyond 90 degrees.

Nail Removal

The nails have been removed in seven cases. The time of nail removal varied between eighteen weeks and thirty-eight weeks, the average being 27.1 weeks. In at least two patients we feel that the nails were removed too soon; in these refracture occurred. In both of these patients bone union was believed to be satisfactory before removal of the nail, but the principal reason for the early removal was the persistence of drainage. After our experience with this group of patients, we feel that the nails should be left in place until either definite bone union or definite non-union is evident on the roentgenogram. The nail should not be removed merely to produce wound healing, although the foreign-body reaction may be a factor in delayed healing. The fixation provided by the nail more than compensates for any ill effects on wound healing due to its presence, so

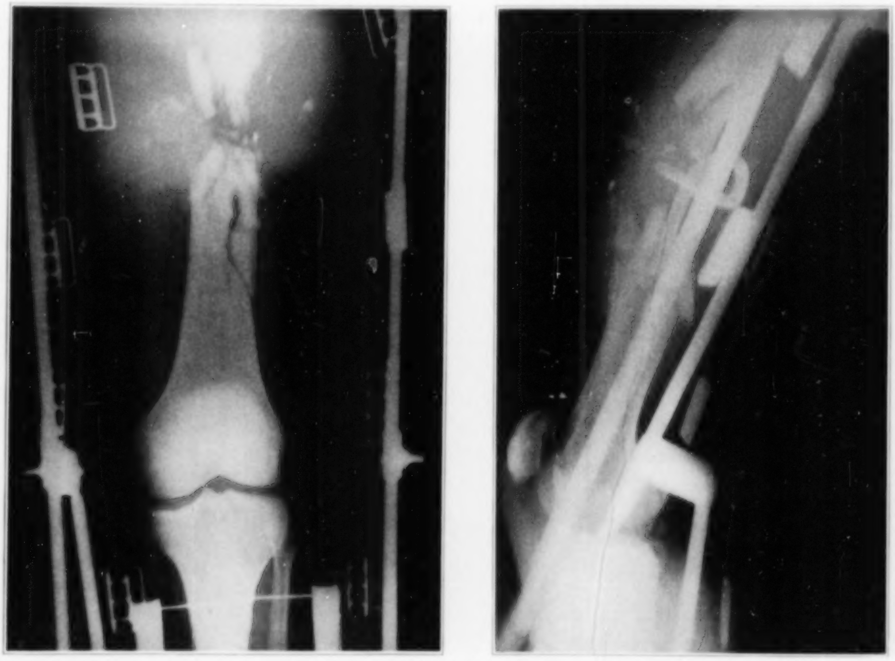

FIG. 5-A

Preoperative anteroposterior and lateral roentgenograms.

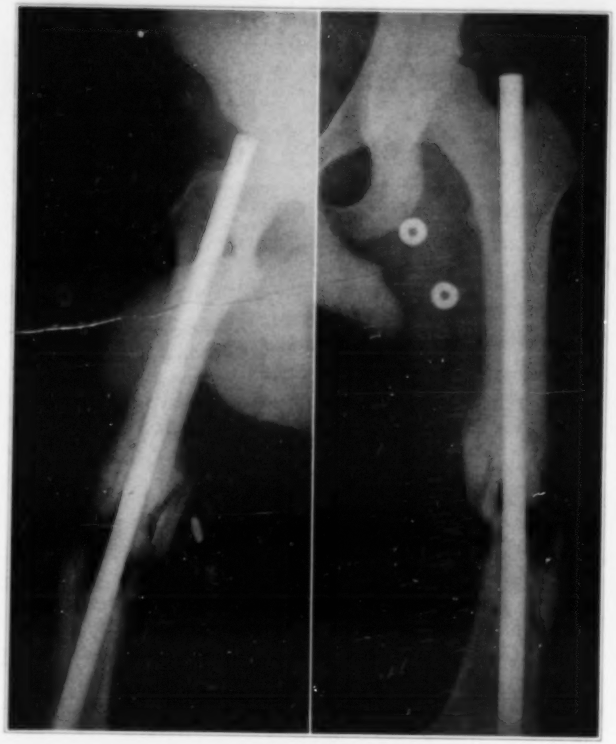

Fig. 5-B

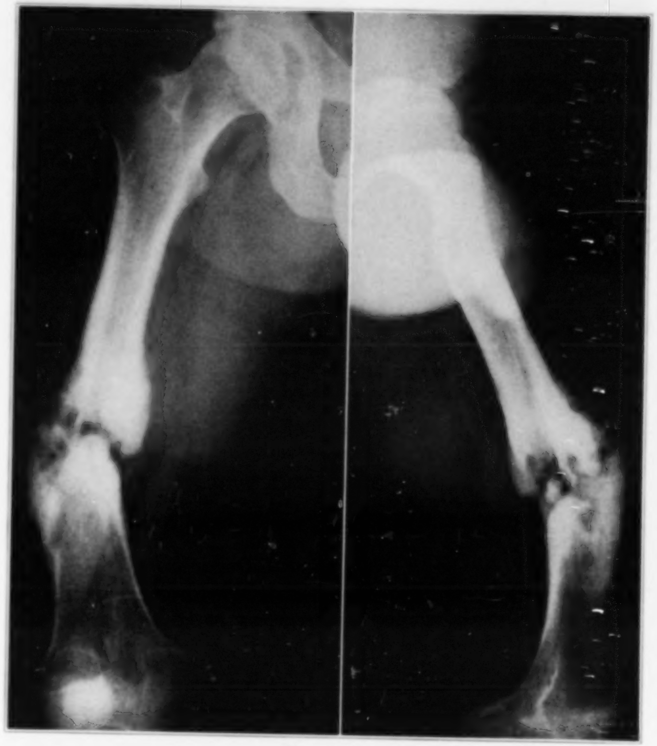

Fig. 5-C

Fig. 5-B: Roentgenograms made five months after operation. Because of obvious non-union and persistent drainage, removal of the nail seemed indicated.

Fig. 5-C: Fifteen months after operation there was non-union of bone, but, because of dense fibrous union, unassisted weight-bearing was possible. The wound had healed completely. (Figs. 5-A to 5-C from Photographic Laboratory, Letterman General Hospital, San Francisco, California.)

long as adequate drainage is maintained. Five of our patients were given ischial weight-bearing braces following removal of the nail, because the roentgenograms showed that bone union was as yet insecure. Permitting the nails to remain for longer periods would have obviated the need for braces.

Period of Hospitalization

The shortest period of hospitalization in this group of patients was four months, the longest twenty months, and the average 13.4 months. This average is extremely high and was due partly to the requirement of the Military Service to maintain the patient in the hospital until he could be discharged from the Service or returned to duty. In civilian practice the hospitalization period could have been markedly curtailed, although in some instances re-admission would have been necessary periodically for additional drainage and sequestrectomy. In this connection it will be recalled that the average time of weight-bearing on crutches was 6.5 weeks.

Eventual Disposition

Our civilian patient was returned to full activity in four months. One military patient was returned to limited duty in six months. The remaining military patients were separated from the Service between twelve and twenty months from the date of operation.

Shortening

There was shortening in all cases, varying between 1.1 and 2.5 inches, with an average of 1.8 inches. This was considered to be a necessary consequence of the operative procedure, because of the required removal of devitalized tissue. A considerable initial loss of bone was noted in most cases because of the nature of the original trauma.

DISCUSSION

The gratifying two-year end results in this small group of patients suggest that increased use of the modified intramedullary nailing procedure might be recommended in selected recent gunshot fractures of the femoral shaft.

It must be emphasized that the primary aim of treatment of recent gunshot fractures of the femoral shaft is the general support of the patient. The most important steps in the operative treatment are the adequate débridement, thorough foreign-body removal, and satisfactory wound drainage. These procedures will never be supplanted by the use of blood and antibiotics, but the latter are of inestimable importance in supporting the resistance of the patient to infection. When possible, delayed primary closure of the gunshot wounds by suture or by skin-grafting should be carried out. After the wound has healed, the ordinary type of intramedullary nailing may be considered for some of these patients, as in closed femoral fractures. The great majority of femoral gunshot fractures will be satisfactorily managed either by traction-suspension or by late intramedullary nailing following satisfactory wound healing without frank infection. In spite of the many advantages of the nailing procedure in making possible early ambulation, ease of transportation, improvement in general well-being, and recovery of joint movement, we do not feel that the method should be applied to recent gunshot fractures except under special circumstances. When it is used indiscriminately by improperly trained personnel and with inadequate facilities, there is still great danger of operative mortality, technical complications at the time of surgery, and spreading wound and bone infection. These sequelae are, indeed, to be feared even under optimum conditions. What then are the indications for the modified nailing procedure?

It is our opinion that modified intramedullary nailing should be considered in recent gunshot fractures of the middle three fifths of the femoral shaft only under the following circumstances:

1. All of the precautions and requisites for nailing femoral-shaft fractures, with the exception of wound healing, must be met.
2. The patient must present one of the following problems:
   - a. Extensive soft-tissue injuries to the involved extremity, so that adequate reduction and immobilization by conservative means are not possible.
   - b. Extensive loss of bone substance, so that contact and alignment cannot be maintained. A reasonable amount of bone shortening is preferable to inevitable non-union.
   - c. Prolonged wound suppuration due to inadequate immobilization, even with traction, satisfactory drainage, and the use of blood and antibiotics.
   - d. Uncontrollable discomfort or progressive debility, so that the outlook by conservative management is unfavorable.
   - e. Associated injuries, notably abdominal and thoracic, the treatment of which necessitates considerable movement of the patient.

Under these circumstances the use of modified intramedullary nailing may curtail prolonged morbidity and may avoid secondary precarious bone-grafting procedures; in some cases it may actually be a life-saving measure. If these circumstances are absent, we strongly recommend the use of traction-suspension as the safest and most effective treatment of recent gunshot fractures of the femoral shaft.

In connection with this modified nailing procedure, it is possible that, in the event of mass casualties, either military or civilian, resulting from bomb explosion, the nailing of selected open fractures of the femoral shaft might be a practical method of providing immobilization, in view of the anticipated shortage of hospital beds. The results which we have demonstrated in our septic cases suggest that, in an atomic emergency, the method might well be used with the assurance that the calculated risk to the patient would be minimal.

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EXPERIENCES WITH INTRAMEDULLARY FIXATION OF COMPOUND FEMORAL FRACTURES IN WAR WOUNDS * †

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With the onset of the Korean conflict, we have again been faced with the problem of war surgery, its infinite variations and unpredictable logistical difficulties. In such a time, it is well to examine critically every method advanced to speed and simplify the care of mass casualties as well as to achieve the maximum restoration of function in each case. The immediate overload of existing facilities in Japan and the institution of air evacuation to the rear placed in our hospitals in this country major casualties as early as fifteen days after wounding, the average time being somewhat longer. From the group of patients arriving at Oakland Naval Hospital, we have gained some slight experience in using intramedullary fixation as a means of stabilizing compound fractures due to missile wounds. These have included open wounds, healed wounds, draining wounds in which infection was evident, and wounds accompanied by major nerve damage. Our series is small and includes only those patients who were operated upon and observed by the authors, and who have been closely followed. In some instances this follow-up has been through communication from medical officers in other hospitals, to which these patients have been transferred.

This paper is not intended as a statistical study. In it, however, some clear-cut implications may be found which time and larger series will substantiate or disprove. I believe that the information and experience gained in this short time should be published for information and evaluation. The patients for whom this method was selected form but a small part of the scores of patients with compound wounds passing through our wards.

In both his earlier and his later reports, Küntscher[5,6] credits Ehrlich with being the first to use intramedullary fixation in compound fractures and Heim with being the first to use it in fresh compound wounds incurred in battle. He further credits Ehrlich with being the first to use such methods of internal fixation to obtain stable osteosynthesis in infected compound wounds. Küntscher stated that absolute rest has been used to prevent and combat infection when such a method is used in compound wounds. He goes on to say that: "Due to the insertion of a marrow nail into a gunshot, the fracture itself is practically eliminated, and we have to deal only with the wound which must be treated in accordance with respective principles of war surgery". In Ehrlich's first fifty-three cases of compound fractures treated with a marrow nail, the average healing time was 67.7 days as opposed to the average healing time of 98.2 days when wire traction and plaster casts were used. The incidence of infection in marrow nailing was only slightly lower than in other methods: 19 per cent. as opposed to 23 per cent. There were 116 compound fractures due to fresh gunshot wounds and infection occurred in 64 per cent. (At that time penicillin was not yet available to these surgeons.)

Böhler has reviewed the evidence rather extensively. Operations in the German Army were for the most part performed under less than perfect conditions and without the aid of penicillin coverage. The rate of infection appears to have been quite high, but no higher than the rate in a similar group of fractures treated by other methods. Böhler expresses the feeling that the use of this method in fractures of the femur is permissible and that with penicillin coverage it offered definite advantages. Haebler has enthusiastically supported use of the intramedullary nail in compound fractures of all bones, particularly the thigh bone. He was the proponent of the complete excision of soft-tissue wounds, stabilization by intramedullary nail, removal of all necrotic bone, and the drainage of the wound through another site in all compound fractures except those below the knee. He advocated leaving the wound open for secondary closure, rather than primary closure as attempted by Böhler. Küntscher's method of treating fresh gunshot fractures considered the wound, but as though it were already infected. Consequently it was left widely open and all pockets of soil and necrotic tissue were removed. He observed that marrow nailing could be carried out during the process of secondary healing. He made the observation, which we have been able to confirm, that, even in cases of the most serious suppuration, wounds above the nails closed.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 30, 1952.

† The opinions herein expressed are entirely those of the authors and are not to be construed as reflecting wholly or in part those of the Bureau of Medicine and Surgery or the Navy Department.

When considering this problem, it would be better that we do not consider the nail as having any inherent merit, but merely as being a method of immobilizing the fracture which permits rest of the soft parts, shortening or impacting of bone fragments, and mobilization of the patient. Destructive osteomyelitis of the localized type is a product of infection and necrosis. It is our belief that in these cases necrotic bone only becomes infected; and, if it is possible to remove necrotic bone, stabilize the limb, and secure soft-tissue coverage, replacement of bone will take place. Often this proceeds by autogenous regeneration without the need of a graft, as we shall demonstrate.

Although our series of cases is small and the period of observation inadequate for final evaluation, the results so far have been encouraging. The nursing care of the patient has been greatly simplified and shortened by the use of intramedullary fixation. Patients with infection were not treated by intramedullary fixation if satisfactory reduction could be obtained and held by balanced traction. We are now beginning to wonder, however, if this choice of treatment is correct in view of the results obtained and the morale uplift resulting from the early mobilization of the patient after intramedullary nailing.

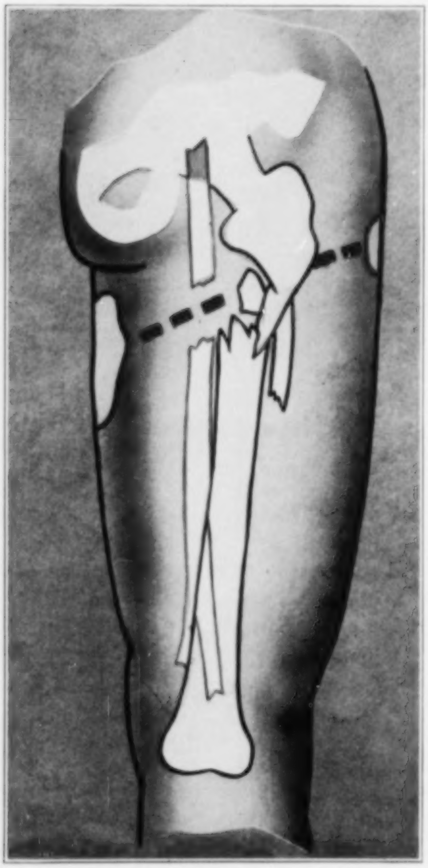

FIG. 1-A

Case 1. P. A. M. The patient had been wounded on September 20, 1950; intramedullary fixation was done on November 9, 1950. Sketch representing compound wound of the thigh with sciatic-nerve damage. (Reproduced by courtesy of National Naval Medical Center.)

TECHNIQUE

It was our custom to remove the plaster casts from all patients with compound gunshot fractures when they were admitted to the Hospital. The involved extremity was then placed in balanced traction and a Kirschner wire was drawn through the tibial tubercle if this had not already been done. For infected wounds, we use a 10 per cent. solution of urethane, containing 1,000 units of penicillin per cubic centimeter. This solution, first proposed by Weinstein in 1946, has been found

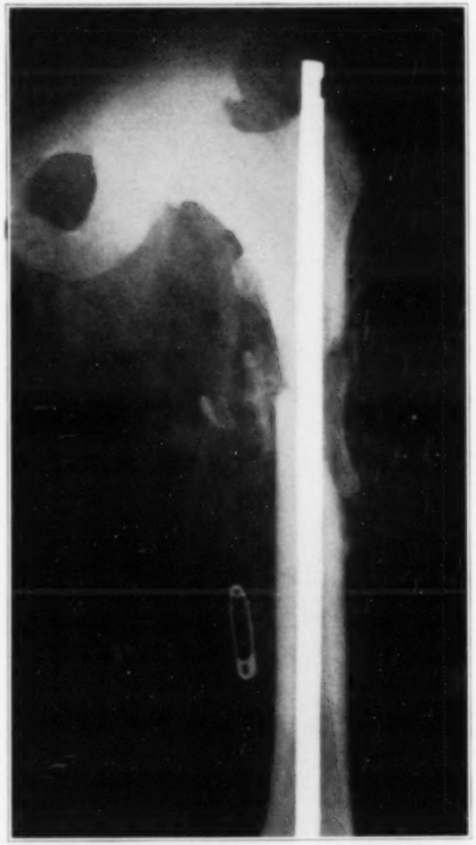

FIG. 1-B

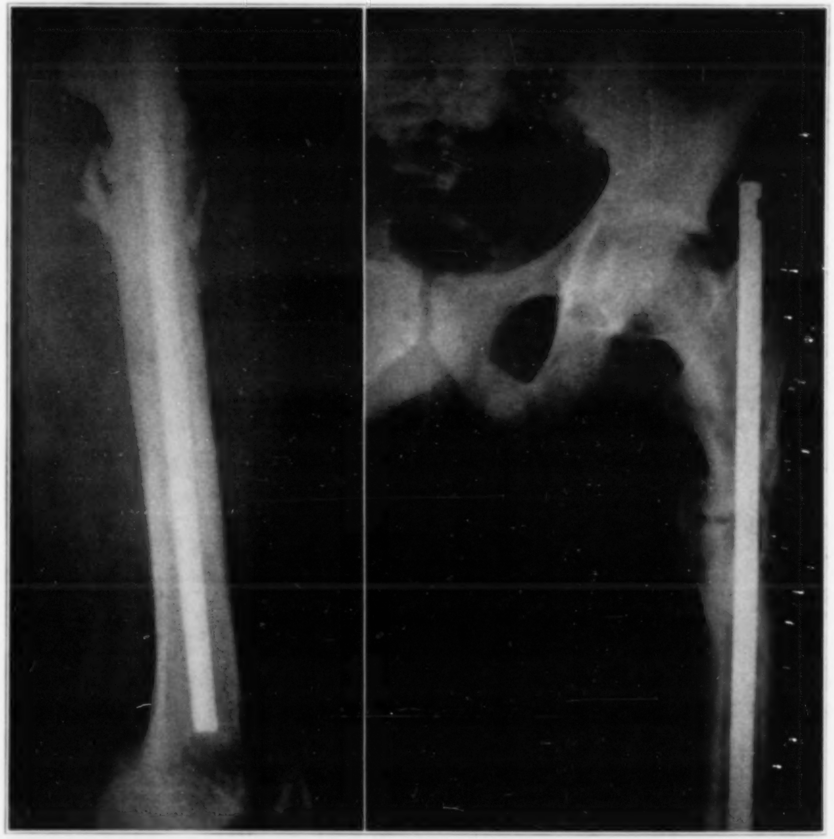

FIG. 1-C

Fig. 1-B: Appearance of fracture immediately after insertion of the intramedullary nail and supplementary bone grafts. (Official U. S. Navy photograph.)
Fig. 1-C: Appearance of the fracture site five months later. (Official U. S. Navy photograph.)

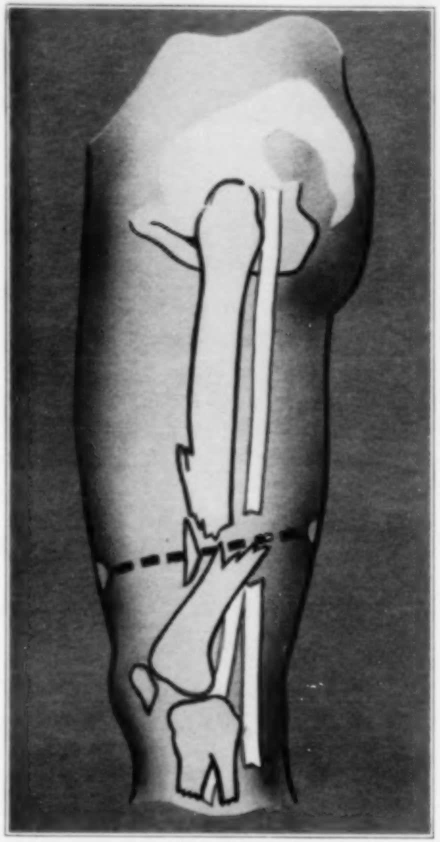

FIG. 2-A

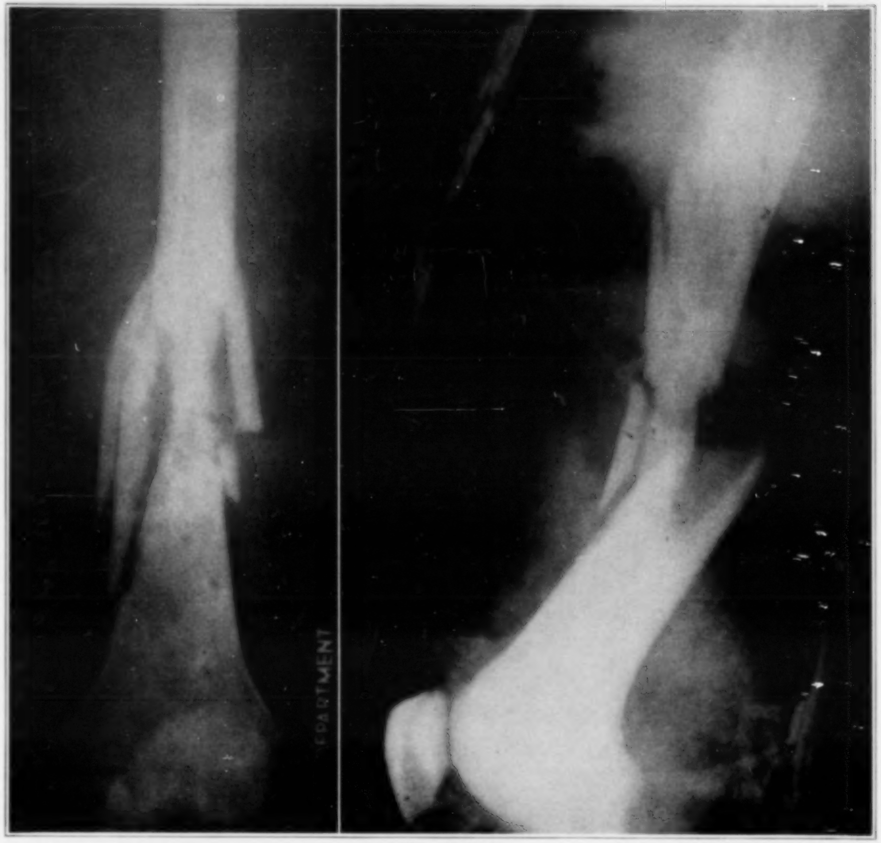

FIG. 2-B

Fig. 2-A: Case 2. C. F. D. Schematic illustration of a compound fracture with laceration of the peroneal nerve. The patient had been wounded September 24, 1950; fixation was done on November 17, 1950. (Reproduced by courtesy of National Naval Medical Center.)

Fig. 2-B: Roentgenogram made at admission. (Official U. S. Navy photograph.)

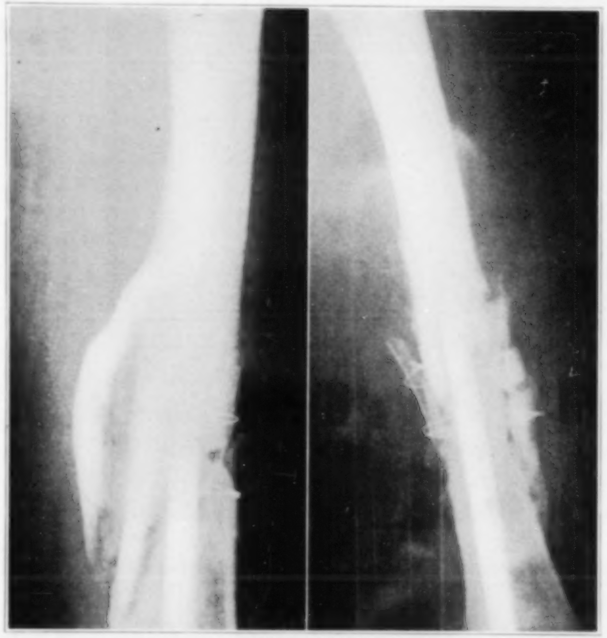

FIG. 2-C

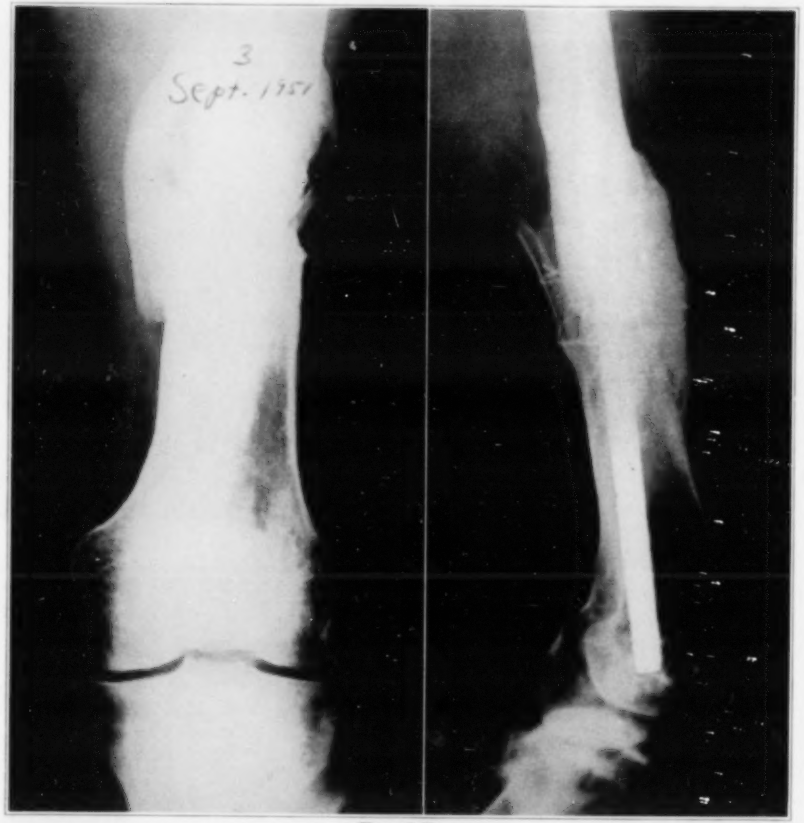

FIG. 2-D

Fig. 2-C: Roentgenogram made five months after fixation and supplementary bone-grafting. (Official U. S. Navy photograph.)

Fig. 2-D: Roentgenogram made ten months after fixation. (Official U. S. Navy photograph.)

especially efficacious in cleaning necrotic wounds. No doubt there are many equally good or better solutions. As data accumulate, we may be able to assess these properly. The authors doubt that one solution will ever be superior to others.

Open wounds were packed loosely with twelve-inch strips of very fine mesh gauze; often a sterile catheter was placed in the depths of the wound to allow frequent irrigation. The gauze was saturated every two to four hours. The dressing was removed and replaced daily or several times a day to keep the wound entirely free of pus and secretion. Penicillin, aureomycin, or streptomycin were given as indicated. Blood was always given as needed to return the hemoglobin and red-blood-cell count to normal levels. An effort was made to bring the hematocrit up to 45 and to maintain it at that level. Those patients with gunshot fractures in whom the soft-tissue wound was found to be healed upon arrival were treated like those with open wounds except that the local penicillin and urethane solution was not administered. Skeletal traction was begun immediately and was adjusted to ensure elimination of the muscle spasm and correction of the shortening which was present upon admission.

It was found that the intramedullary nailing was made much easier if there was no

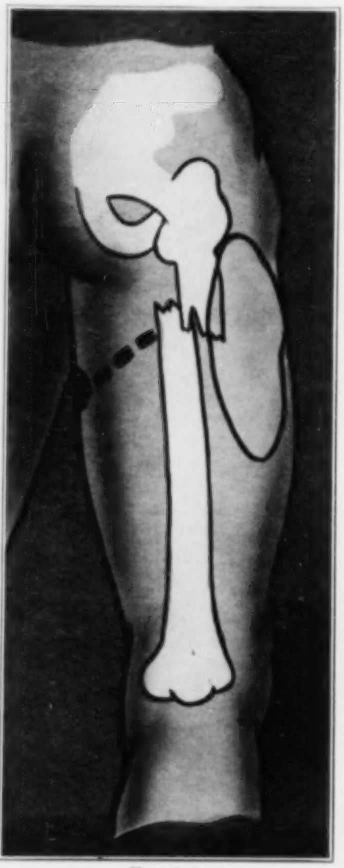

Fig. 3-A

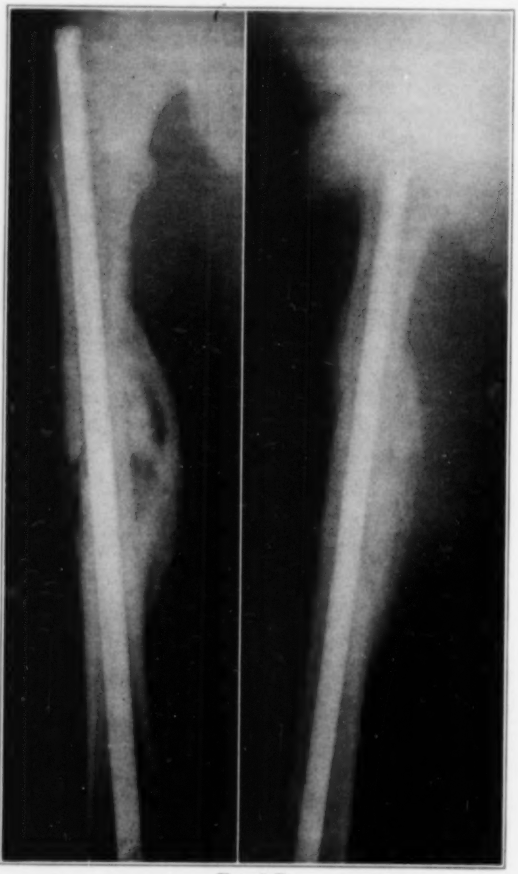

Fig. 3-B

Fig. 3-A: Case 3. S. T. Schematic drawing of a compound fracture of the upper third of the femur. The patient had been wounded November 3, 1950; fixation was done forty-two days after the fracture, following secondary closure of the wound. (Reproduced by courtesy of National Naval Medical Center.)

Fig. 3-B: Roentgenogram made October 18, 1951, ten months after fixation, showing healing of the fracture. (Official U. S. Navy photograph.)

shortening or if even a slight separation of the fracture existed. A compound fracture of the femur is not an emergency which calls for immediate nailing, especially if it is in balanced traction. It appears best to correct the shortening before intramedullary nailing is attempted. If the shortening had not been overcome by the time the wound was cleaned, a secondary closure was done prior to the nailing and the traction was increased. In those cases of compound fracture in which the femur was exposed, nailing was usually done through the open wound, while in those cases in which the soft-tissue wound was healed, the nailing was done through a posterolateral approach along the lateral intermuscular septum. Cultures were taken from the depths of the wound at the time of surgery and sequestra and foreign bodies were removed. During the surgery the wound was frequently irrigated with copious amounts of normal saline solution. The proximal and distal fragments were mobilized and the soft tissues were protected with a pack. The medullary contents of both the proximal and the distal ends of the femur were removed by means of a hand reamer, continuous saline irrigation being used during this procedure. A solid guide wire was passed proximally from the fracture site through the trochanter to the skin, and thereafter the method followed the usual retrograde technique of open reduction and nailing of fractured femora as practised in this country. All of our nails were of the clover-leaf or Küntscher type, none being of the solid diamond-shaped or triflanged type. In each of our cases, we attempted to overcome as much shortening as possible, even where there was marked bone loss; when we found some bony spicules in apposition at the ends of the fragment which would give us the full length, we attempted to maintain this. We planned on later restoration of bone circumference by bone-grafting procedures. It will be evident from some of the cases to be discussed that in some instances the regenerative power of the retained soft tissues and the periosteal fragments was such that bone-grafting procedures were not needed. Whenever an open wound was not healed it was left open and packed with fine mesh gauze as described previously. A catheter was placed in the wound for injection of the irrigating solution.

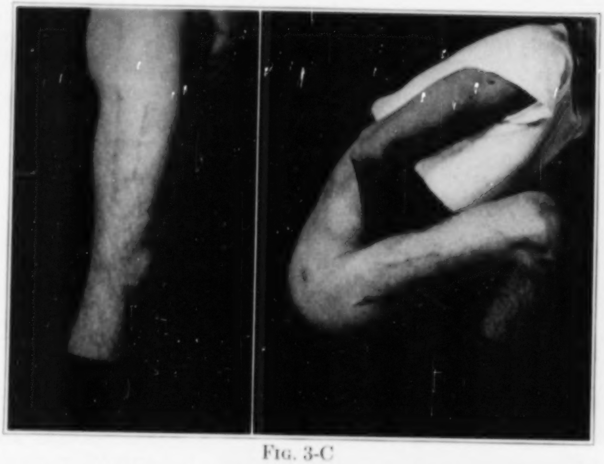

FIG. 3-C

Appearance of the extremity and range of motion ten months after fixation. (Official U. S. Navy photograph.)

If the soft-tissue wound had healed prior to surgery, it was closed tightly. Penicillin in the amounts of 300,000 to 600,000 units was given intravenously during the surgery. In each instance as much as 1,500 cubic centimeters of whole blood was cross-matched and available for the operative procedure. Although Küntscher stressed that operative periods must be kept to a minimum and that, if the operation could not be accomplished in one hour, it should be discontinued, we found that periods up to three hours were often necessary. In these cases, this produced no apparent effect of shock. It was our custom to discontinue skeletal traction after the intramedullary nailing. In those cases in which doubt existed as to lateral stability of the fracture with a rotational factor of the distal end of the femur about the medullary nail, a plaster boot was applied with a cross piece attached just proximal to the heel. This allowed knee motion and at the same time prevented rotation of the distal femoral shaft upon the proximal. We allowed our patients to move their extremities as soon as comfort permitted. Most of the patients were allowed up, out of bed, and in a wheel chair within a few days. Those with stable fractures were allowed to be on crutches approximately one week after nailing, but without weight-bearing.

The following case histories of those patients whom we operated on in November and December 1950 and January 1951 will show in detail the different situations encountered and the results obtained so far.

CASE HISTORIES

CASE 1. P. A. M., Private First Class in the Marine Corps, twenty-one years old, was admitted to the Oakland Naval Hospital on October 25, 1950, with a compound fracture of the upper portion of his left femur, suffered on September 20, 1950. Examination revealed multiple wounds of the left lower extremity, including a draining wound on the anterior surface of the thigh, four inches below the inguinal ligament, and a similar wound posteriorly. There was a six-by-three-inch open wound on the calf of the left leg and two small wounds on the dorsum of the left foot. He presented a foot-drop on the left and evidence of sciatic-nerve laceration. Open treatment of the wound, with penicillin and urethane solution for irrigation, was instituted, and he was given 300,000 units of penicillin intramuscularly twice daily. Roentgenograms made on the day of admission showed a shattering type of gunshot fracture which involved the upper third of the femur distal to the lesser trochanter. One comminuted fragment joined the upper and lower fragments, but the continuity was unsatisfactory, as there was both medial and anterior displacement (Fig. 1-A). During this treatment the drainage ceased and the wounds became covered with healthy granulation tissue. Acceptable reduction was not effected and on November 9, 1950, an open reduction was performed. The intramedullary nail was placed in the femur through an approach along the posterolateral intermuscular septum. At the time of surgery, the larger bone fragment appeared healthy and was replaced as a bone graft to fill a defect in the lateral portion of the femur at the fracture site (Fig. 1-B). The sciatic nerve was not exposed, since exploration at a later time was recommended by our neurosurgical consultant. The surgical wound was closed and a skin graft was placed over the defect in the area of the gastrocnemius in the left leg. Culture taken from the fracture site at the time of surgery showed no growth. It was impossible to prevent the distal femoral fragment from rotating on the medullary pin at the time of surgery. A plaster boot was therefore applied to the left leg to prevent rotation as well as to overcome the foot-drop. The postoperative course was uneventful and the wound healed without drainage. The patient was transferred to a hospital on the East Coast on December 7, 1950.

Records from the receiving hospital showed that the wound remained closed and that the patient continued to do well, except that an external rotation of the lower femoral fragment developed. On February 1, 1951, the lower portion of the left sciatic nerve and the upper portion of the peroneal and tibial nerves were explored. The nerves were found to be intact, but adhesions were present and these were severed. As the nerve had shown little return of function, it was re-explored and anastomosis of the lacerated ends was done on April 30. Orthopaedic examination by Commander Howell Wiggins, Naval Hospital, Philadelphia, on that date revealed that there was a 45-degree external rotation deformity of the left thigh due to two factors: (1) allowing the left lower extremity to lie constantly in external rotation and (2) healing of the fracture with rotation of the distal fragments. There was one-half inch shortening of the left lower extremity. The roentgenogram at that time showed excellent healing (Fig. 1-C), and the patient was allowed to continue full weight-bearing without the aid of crutches.

He appeared before a Physical Evaluation Board in

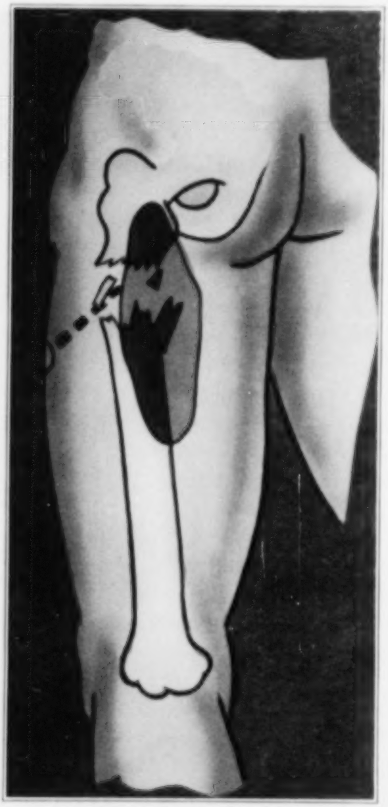

FIG. 4-A

Case 4. M. M. The patient had sustained a shattering-type fracture of the upper third of the femur with marked soft-tissue infection. There was an open draining wound at the time of fixation, which was done twenty-three days after injury. The patient had been wounded November 28, 1950; fixation was done December 22, 1950. (Reproduced by courtesy of National Naval Medical Center.)

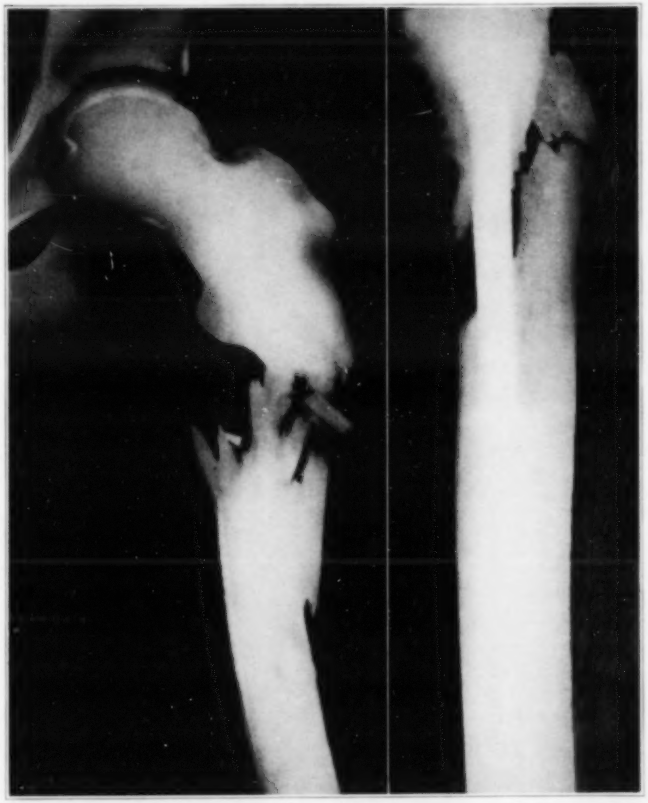

FIG. 4-B

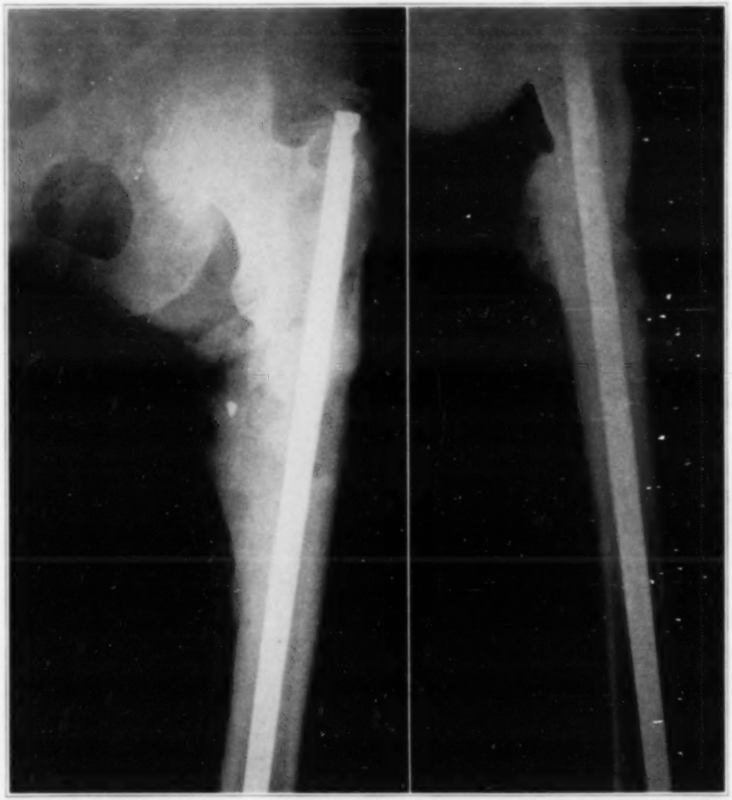

FIG. 4-C

Fig. 4-B: Retouched roentgenograms of the fracture site, made before fixation. (Official U. S. Navy photograph.)

Fig. 4-C: The roentgenogram shows healing of the fracture ten months after fixation. No supplementary bone-grafting procedures had been required. (Official U. S. Navy photograph.)

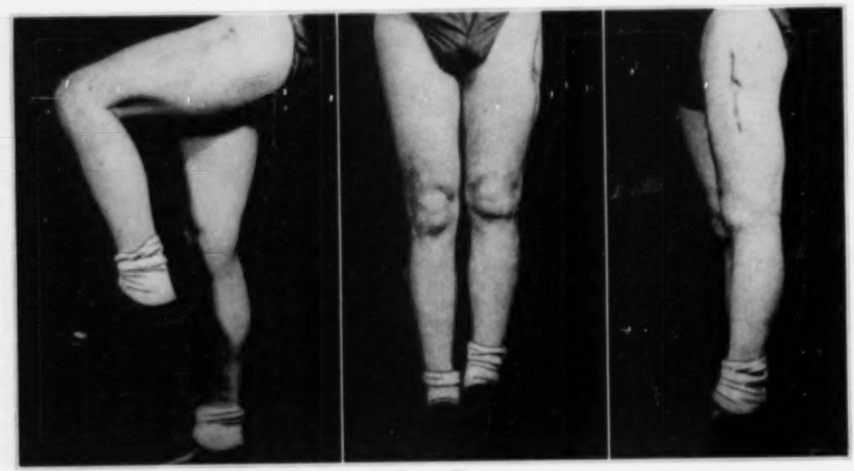

FIG. 4-D

Appearance of thigh and range of knee motion eleven months following fixation and twelve months following wounding. Shortening of left leg has been compensated by an elevated shoe.

July and was given a medical discharge. At that time the sciatic nerve showed clinical signs of regeneration following the anastomosis. The femur had 45 degrees of external rotation. Flexion of the knee was to 90 degrees, extension to 180 degrees; atrophy of the left thigh amounted to two inches. He had been allowed unrestricted weight-bearing in spite of swelling due to injuries to the leg and foot. Since his discharge the patient has failed to answer several letters written him to gain information on range of knee motion, return of sciatic-nerve function, and other symptoms.

CASE 2. C. F. D., Private First Class in the Marine Corps, twenty-two years old, received a compound fracture of the left femur from enemy rifle fire on September 24, 1950. He was sent first to the Medical Battalion where the wound was debrided and a body spica was applied. During transfer from there antibiotic therapy was administered. He was treated next at the United States Naval Hospital, Yokuska, Japan, where the cast was changed and a Steinmann pin was inserted in the left tibial tubercle. Antibiotic therapy was continued in transit to the United States. He was admitted to our Hospital on October 25, 1950. At this time we removed the cast and found that he had a healed soft-tissue wound, so that the left limb could be placed in balanced skeletal traction. Neurological examination revealed complete loss of function of the left peroneal nerve. Roentgenographic examination of the left femur showed a markedly comminuted fracture at the juncture of the middle and lower thirds (Figs. 2-A and 2-B). There was 10 degrees of posterior bowing associated with separation of the large comminuted fragments. It was agreed in consultation with the Neurosurgical Staff that repair of the peroneal nerve should be done at the earliest possible moment, but should be postponed until there was stability at the fracture site. Penicillin therapy was continued. The temperature was occasionally elevated, but never above 100 degrees. The posterior bowing was not corrected by skeletal traction or by manipulation at the fracture site with countertraction. On November 17, 1950, satisfactory reduction was effected by insertion of an intramedullary nail through a posterolateral incision. The old scar and fibrotic tissue were excised along with several sequestra of bone of fairly large size. To replace the loss of bone, a rib from the bone bank was cut into strips, which were placed about the fracture site and secured with two circumferential wire loops. The operative wound was closed with drainage. The culture taken from the area of the fracture at the time of surgery revealed no growth on routine media. The wound healed *per primam* and the sutures were removed on November 24, 1950.

The patient was then transferred to the Neurosurgical Service and a peroneal neurorrhaphy was done on January 10, 1951. It was necessary to excise 2.5 centimeters of the left peroneal nerve. Following this the patient was returned to a body spica with the hip in hyperextension and the knee flexed 45 degrees to prevent distraction of the sutured nerve. It was necessary to keep him in this cast until February 14, 1951. On removal of the cast, he had the usual marked oedema of the left foot, which gradually disappeared with physical therapy and paravertebral blocks. The wound was sufficiently healed for him to be fitted with an ischial weight-bearing brace on April 16, 1951. Roentgenograms made at about this time showed rather far advanced healing at the fracture site (Fig. 2-C) and the patient was allowed to depart on thirty days' leave. He had at that time extension of 180 degrees and flexion of 90 degrees in his knee joint. The Tinel sign was positive approximately two or three inches below the head of the fibula.

By October 1951, he was wearing a single-bar foot-drop preventor brace. His knee motion approached normal and there was excellent development of his thigh musculature. There was one and one-half inches of shortening of the extremity, which was corrected by an appropriate elevation in the heel.

Case 3. S. T. This patient was a twenty-year-old hospital corpsman who received a compound comminuted fracture of the right femur on November 3, 1950, after being struck by a forty-five-caliber bullet. He was admitted to our Hospital on November 21, 1950, with an open granulating wound on the lateral side of the right thigh, measuring approximately six by three inches. Roentgenographic examination of the thigh revealed a comminuted fracture of the femoral shaft near the juncture of the middle and upper thirds (Fig. 3-A). There was posterior angulation and medial displacement at the fracture site.

This wound responded well to irrigation with the penicillin and urethane solution and a secondary closure was performed on November 30, 1950. At this time the position of the femoral fragments remained unsatisfactory and, after wound closure was obtained, an intramedullary nail was inserted on December 15 through a new lateral incision along the lateral intermuscular septum. In this instance, the fracture was quite stable and no cast was required for rotatory stability. The surgical wound healed by primary intention. A culture made at the time of surgery revealed no growth on routine media, and the postoperative course was uncomplicated. Early motion and physical therapy were possible. On April 13 the patient was sent on limited duty as a hospital corpsman on the staff at the Naval Hospital. This man became exceedingly active and it was difficult to obtain follow-ups on him, even though he was on the staff of the Hospital.

In October 1951 roentgenograms showed excellent advance in healing (Fig. 3-B). There was no evidence of infection, and no particular discomfort. The nail remained in place. Photographs (Fig. 3-C) made at the same time show the range of motion which he had obtained in the knee and the development of the thigh and calf musculature.

Case 4. M. M. This was a staff sergeant in the Marine Corps, thirty-six years old, who was injured by machine-gun fire in Korea on November 28, 1950. At that time his wound was dressed and a Thomas splint was applied. He then waited six days in a cold tent, mainly in sub-zero weather, his only treatment being an occasional injection of morphine to relieve the pain. He was evacuated to Japan on December 6 and the wound was redressed. Antibiotic therapy was started, a hip spica was applied, and he was transferred by air to the West Coast of the United States. Upon admission to our Hospital, his temperature was 100 degrees, pulse rate 96, respiration 20. His red-blood-cell count was slightly below normal, with a hemoglobin of 13.5 grams. Removal of the spica cast revealed a defect of eight by twenty centimeters in the soft tissues overlying the fracture site in the upper portion of his left thigh. The femur was found to be visible through the open wound and there was a purulent exudate. A few metallic fragments were embedded in the area of the fracture and some were visible. There was an area of frostbite, four centimeters in diameter, on the posterior surface of the left heel, and both feet were slightly frostbitten. A roentgenogram of the femur made at the time of admission (Fig. 4-B) revealed a badly comminuted fracture involving the shaft slightly below the juncture of the shaft with the neck. A segment of the shaft about five centimeters in length was found to be severely comminuted and fragmented. There was lateral rotation of the neck fragment.

The patient's thigh and leg were placed in balanced skeletal traction; the wound was packed open with fine mesh gauze, and saturated with penicillin and urethane solution applied by means of a catheter placed in the depths of the wound. Penicillin and aureomycin were given systemically. Within a few days the appearance of the wound improved and it became covered with healthy granulation tissue. However, acceptable position of the fragments was not obtained in traction, and on December 22, 1950, through an enlargement of the wound, débridement was done and stability was effected by means of an intramedullary pin. A culture made at the time of surgery revealed a heavy growth of *Proteus vulgaris*.

Following the insertion of the nail, with removal of the dead and necrotic tissue from around the fracture site, the wound was packed open with fine mesh gauge. This was kept constantly saturated with our irrigating solution. The fracture was very unstable, yet we were anxious to avoid any form of rigid internal metallic fixation which might hold the fragments apart. Accordingly a plaster boot was applied with a cross bar to prevent external rotation of the distal fragment. The top of this cast was removed so that the foot could be dressed daily to take care of the necrotic area on the heel. This man had a temperature rise to 100.8 degrees on the sixth day after operation, but his temperature had returned to his preoperative level of 99.8 degrees on the seventh day. Gradual closure of the wound was effected by means of wire sutures which had been placed in the skin edges at the time of surgery and which were tightened when the dressings were changed. The wire sutures were removed on January 4, at which time the wound was considerably narrower. Soft-tissue healing was complete by January 13, except for a sinus in the mid-portion of the wound. Beginning on February 2, he was allowed to be in a wheel chair. The drainage became of a clear serous type and had stopped completely by February 15, 1951.

A roentgenogram made January 15, 1951, revealed considerable bony repair, with excellent position and alignment, which was maintained by an intramedullary nail. Bridging was not complete anteriorly, where there was loss of bone substance, but the plaster boot was discontinued and the patient was allowed to use his crutches. We were unable to fit him with an ischial weight-bearing brace, as the frostbitten area of the left heel prevented the wearing of a shoe. The patient went on a thirty days' leave on March 20, 1951, walking with the use of crutches, swinging his knee, but bearing no weight. Upon his return on April 20, there was no drainage and the wound was quite solidly healed, without induration or tenderness. A roentgenogram of his left femur revealed far advanced healing. At this time, measurement of the lower extremities revealed three centimeters of shortening of the left leg; the circumference of the upper portion of the left thigh, 20 centimeters above the patella, was 51 centimeters, that on the right, 45.5 centimeters; the circumference of the mid-calf region on the left was 36 centimeters, on the right, 36 centimeters. There was flexion of 100 degrees and extension of 180 degrees at the knee joint. The patient had gained twenty-five pounds in weight. He was transferred at his own request on May 8, 1951, to the Naval Hospital at Oceanside, California.

It should be mentioned that this was one case in which we attempted to get soft-tissue healing and some degree of stability at the fracture site, with the full expectation of having to do an additional osteoplastic procedure at some future time, possibly one and a half or two years later. We were struck in this case and in others by the remarkable regenerative power of bone when immobilization is accomplished and blood supply is provided by the removal of necrotic scar tissue and bone.

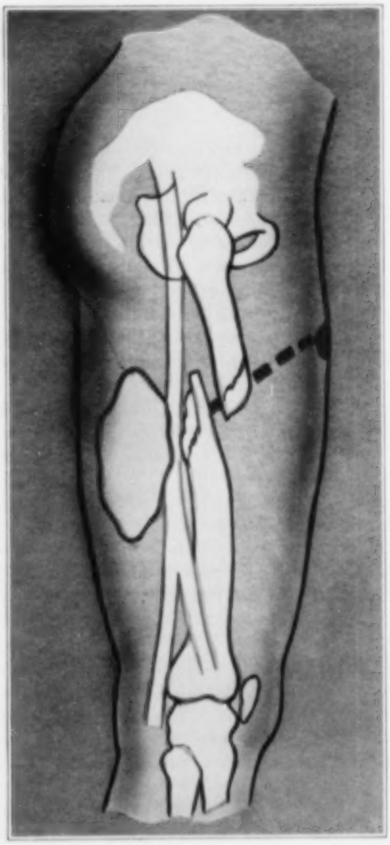

FIG. 5-A

Case 5. A. A. Schematic drawing of an infected compound fracture, which had been internally fixed thirty-four days after injury. Injury was on December 2, 1950, fixation on January 5, 1951. Primary closure was unsuccessful; infection supervened. (Reproduced by courtesy of National Naval Medical Center.)

Commander Cantrell, Naval Hospital, Oceanside, reported that this sergeant was returned to limited duty at the Marine Base, Oceanside, California, in July 1951. At a follow-up examination in November 1951, a large mass of callus was revealed, which was forming trabeculated bone at the fracture site (Fig. 4-C). There had been no record of drainage. The thigh musculature was developing well. He had 90 degrees of knee flexion and complete extension. The calf muscles had regained their normal power. The shortening of the extremity was compensated readily by a lift in the shoe (Fig. 4-D).

CASE 5. A. A. A twenty-year-old Private First Class in the Marine Corps was admitted to the Hospital on December 18, 1950. He had been wounded in action on December 2, 1950. In addition to a compound fracture of the right femur, he had sustained frostbite in all his fingers and toes, a shrapnel wound of the right wrist, and a traumatic amputation of the left index and middle fingers. There was a large soft-tissue defect over the posterolateral aspect of the right thigh in its middle third (Fig. 5-A). The defect measured approximately five centimeters in diameter, but was not deep enough to expose bone. All of his wounds were treated with wet dressings and the right lower extremity was placed in balanced skeletal traction. A roentgenogram made on December 23, 1950, showed a spiral fracture of the middle third of the shaft of the femur with posterior displacement of the distal fragment of more than one shaft diameter. Numerous fairly large metallic particles were found in the region of the fracture site and in the soft tissues in the upper portions of the thigh. Satisfactory position of the fracture fragments was not obtained with skeletal traction, but the soft-tissue wound of the right thigh responded well to the wet dressings.

On January 5, 1951, open reduction with insertion of the medullary nail was performed. From a culture made from the depths of the wound at the fracture site, a heavy growth of *Pseudomonas fluorescens* developed. This operative wound along the lateral intermuscular septum was closed with a drain. The soft-tissue missile wound was undercut and partially closed by approximation of the undercut skin with interrupted cotton sutures. Because of lateral rotation of the femur after insertion of the nail, a plaster boot with a cross bar was used in this case.

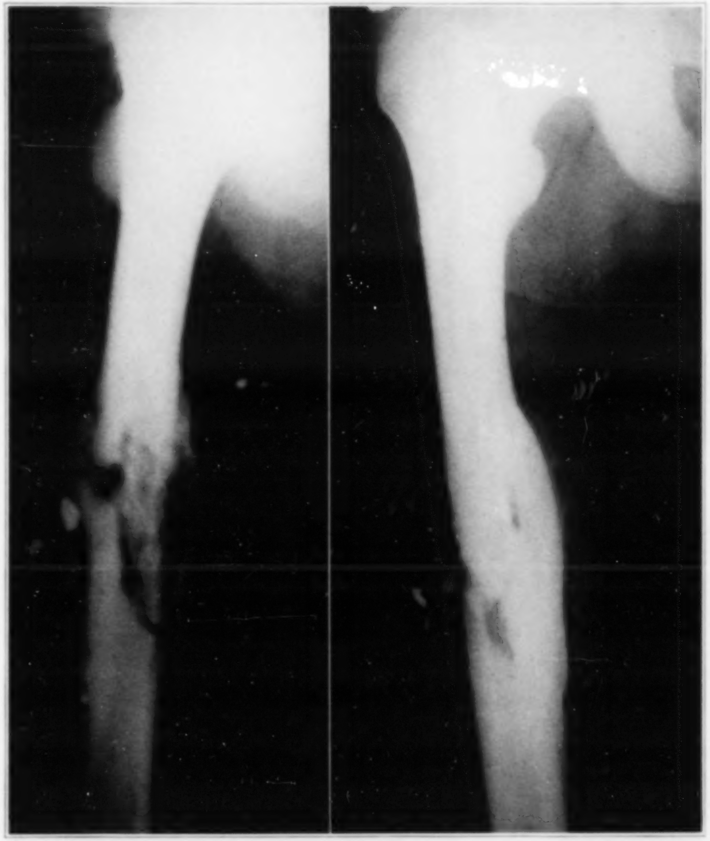

Fig. 5-B

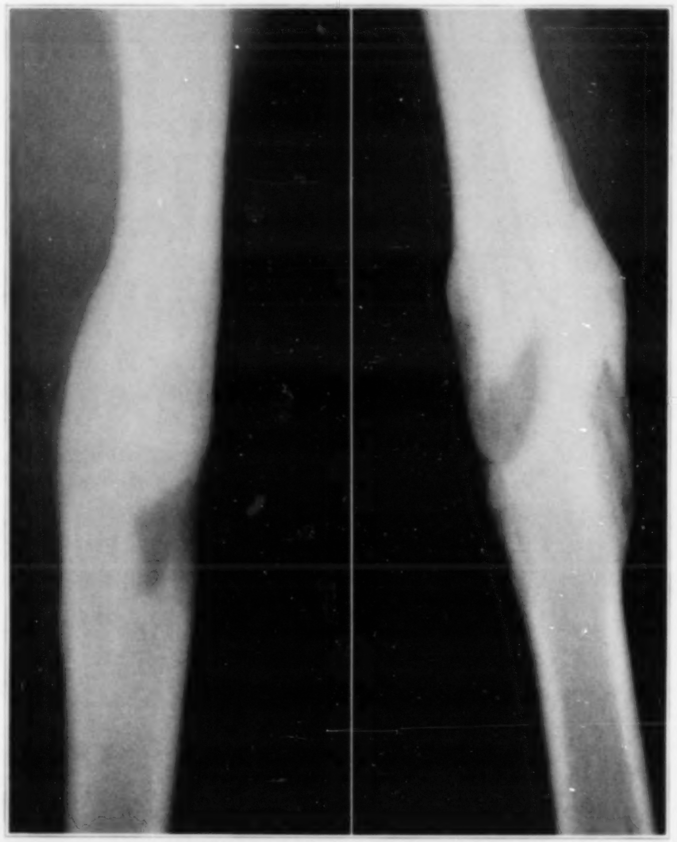

Fig. 5-C

Fig. 5-B: Appearance in June 1951, following removal of the nail. Note residual sequestration. (Official U. S. Navy photograph.)
Fig. 5-C: Appearance in December 1951. The sinus has been closed for two months. Note residual osteitis. (Official U. S. Navy photograph.)

This patient had a somewhat alarming postoperative course, his temperature rising to as high as 101 degrees and pulse rate varying from 100 to 120 degrees for seven days. At the end of this time a serosanguineous drainage began from the wound over the trochanter and from the site where the drain had been placed in

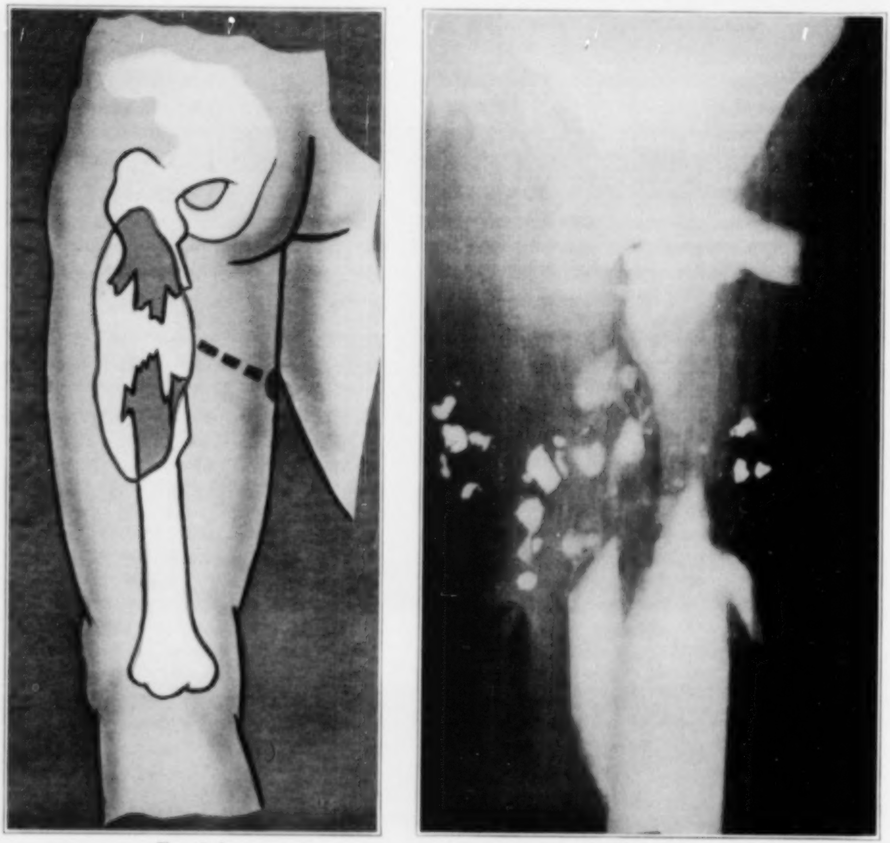

Fig. 6-A

Fig. 6-B

Fig. 6-A: Case 6. W. W. M. Schematic drawing representing extensive comminution with loss of bone substance and marked soft-tissue destruction. The patient had been wounded November 7, 1950; fixation was done January 5, 1951. (Reproduced by courtesy of National Naval Medical Center.)

Fig. 6-B: Roentgenographic appearance two months after wounding, at the time of internal fixation. (Official U. S. Navy Photograph.)

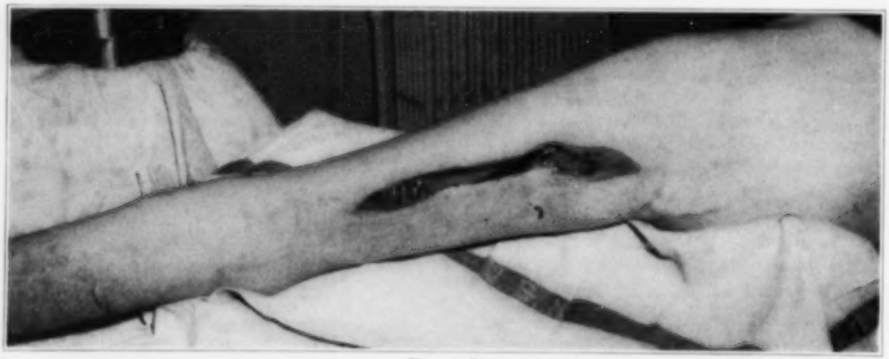

Fig. 6-C

Showing open granulating wound one month after internal fixation of the fractured femur. (Official U. S. Navy photograph.)

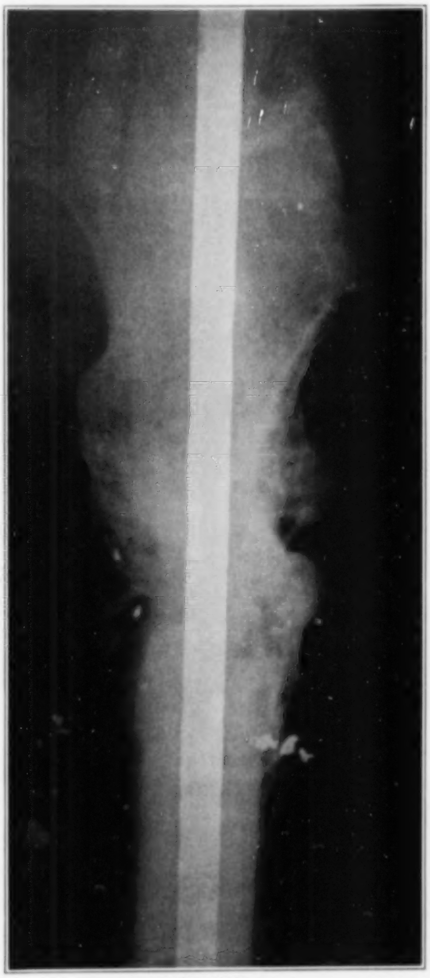

FIG. 6-D

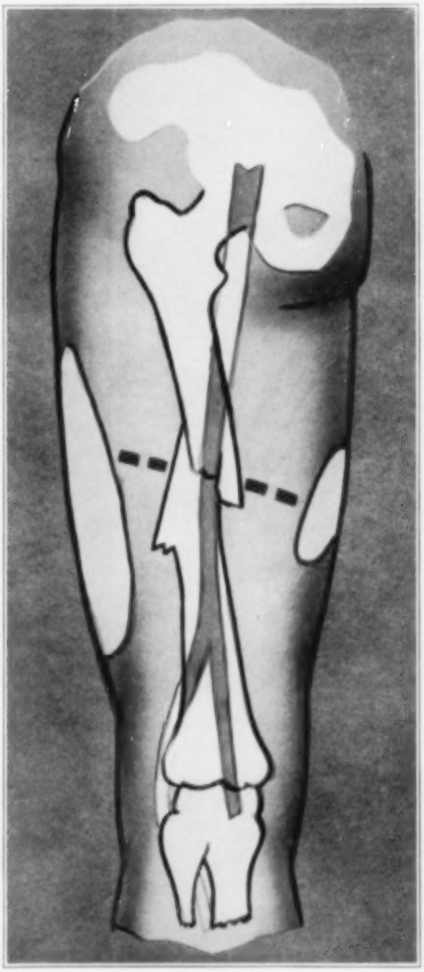

FIG. 7-A

Fig. 6-D: Showing healed fracture with residual infection ten months after fixation. Note re-formation of bone in presence of sequestration. (Official U. S. Navy photograph.)

Fig. 7-A: J. F. T. Fixation, with removal of a large loose fragment, was done twenty-two days after wounding. The injury had been sustained December 7, 1950. (Reproduced by courtesy of National Naval Medical Center.)

the operative wound. His temperature promptly dropped and his pulse rate fell to between 80 and 110. By February 13, 1951, he was fit for transfer to the United States Naval Hospital in Philadelphia, Pennsylvania. At that time he had a moderate serosanguineous drainage from the lateral wound. The nail was removed on June 11, 1951, approximately five months after operation (Fig. 5-B), because of apparent early union and some gluteal pain. There was drainage from both the sinus in the lateral aspect of the thigh and the wound over the trochanter until about the first week in July. After several weeks drainage recurred, and on October 1 a sequestrectomy and a currettement of granulation tissue in the bone defect were done. The wound healed by first intention, then broke down and drained for two weeks, after which drainage stopped and did not recur (Fig. 5-C).

When last seen he had full extension, lacking only five degrees of full flexion. He had no angulation, and only one-half inch of atrophy of the right thigh with one-half inch of shortening. He walked without a limp.

CASE 6. W. W. M., a Private First Class in the Marine Corps, twenty-two years old, had been wounded in action against the enemy on November 7, 1950, when he was struck by rifle fire in his left thigh. He arrived at the United States Naval Hospital, Oakland, on November 28, 1950. On admission the cast was found to

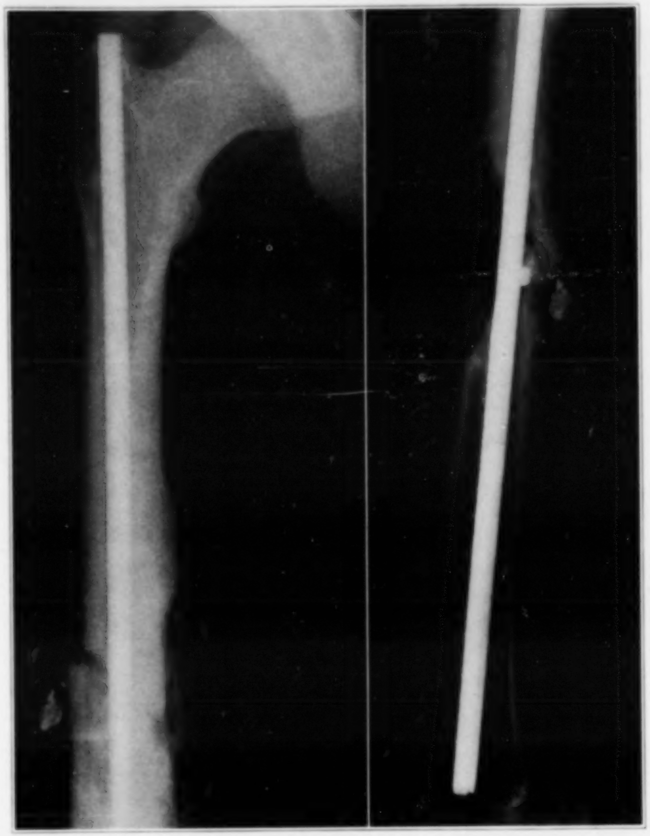

FIG. 7-B

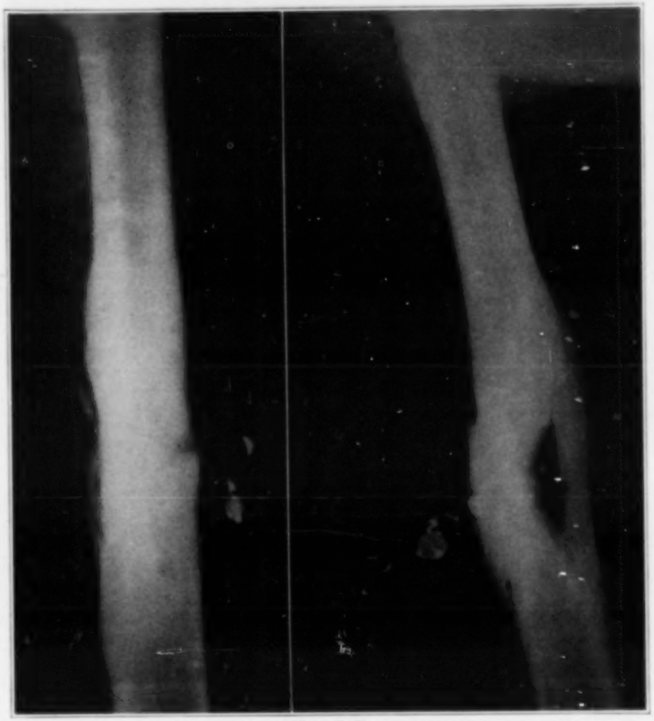

FIG. 7-C

Fig. 7-B: Anteroposterior and lateral roentgenograms of the fracture site, made in early May 1951. Considerable mature callus was present, but a defect in bone persisted where a detached bone fragment was removed during insertion of the intramedullary nail. Note the early bone formation at the fracture site. (Official U. S. Navy photograph.)

Fig. 7-C: The roentgenogram shows a healed fracture with central defect, seven months following insertion. The nail has been removed. The soft-tissue wounds have remained closed. (Official U. S. Navy photograph.)

be soaked with a foul, fecal-smelling, purulent discharge. He was in extreme pain, emaciated, and in protein imbalance. His mental attitude was extremely poor, and he was apathetic and refused to eat. He was removed from his cast and placed in balanced skeletal traction. There was a very large wound of exit on the posterior surface of his left thigh (Fig. 6-A), varying from five to eight centimeters in width and extending almost the entire length of the thigh. On the anterior surface of the thigh, there was a large soft-tissue defect measuring fifteen by three centimeters, which was granulating fairly well. The posterior wound extended down to the fracture site of the femur, and from the depths of the wound a creamy purulent exudate was draining, with a definite fecal odor. Roentgenograms made at admission revealed a shattering-type fracture of the femur beginning at a point about five centimeters below the greater trochanter with such extensive comminution and shattering as to amount to complete disruption of the femoral-shaft architecture over a distance of approximately ten centimeters (Fig. 6-B). This man required large doses of demerol for relief of his pain. The open wounds were carefully explored and packed with fine mesh gauze with a catheter for irrigation as described above. This man proved to be one of our most difficult nursing problems. Pressure areas on the buttocks, over the iliac crests, and over the sacrum were constantly developing. Tube feeding was necessary a great part of the time. Gradually the soft-tissue wounds began to clean up to some extent, but they were constantly being contaminated by the drainage associated with the massive sequestra in the depths of the thigh.

By January 5, the patient was considered sufficiently improved to undergo a rather precarious procedure. On this date a sequestrectomy was performed and stabilization was effected by means of an intramedullary nail. The fracture was approached again through an incision along the lateral intermuscular septum, so that the large soft-tissue wound on the posterior surface of the thigh, which was the site of the drainage, could be by-passed. A large number of sequestrated, completely free and necrotic bone pieces were identified and removed, an old abscess cavity was identified, and its walls were curetted. A culture from this cavity showed a growth of colon organisms. After stabilization of the femoral fragments and removal of a considerable amount, but by no means all, of the necrotic bone fragments, the wound on the posterior surface was opened more widely and fine mesh gauze was packed in the wound in an effort to eliminate all abscess pockets. Rubber catheters were again inserted for irrigation of the depths of the wound, allowing for "sump" or dependent drainage through the widely opened posterior wound. The lateral surgical wound was closed, but a drain was used along the entire length of the wound. During the surgical procedure 1,500 cubic centimeters of blood was given and he received an additional 500 cubic centimeters daily for the next two days. The postoperative course was alarming but not violent. The temperature rose to 102.6 degrees with a correspondingly rapid pulse on the third day after operation. By the fifth day it had subsided to 99.6 degrees and the pulse rate had dropped to 130 per minute. It was almost immediately noticed that the nursing care was simplified and when he was turned he experienced much less pain than before. A plaster boot and a lateral bar were used to prevent rotation of the femur on the nail, as the fracture site was extremely unstable.

After surgery there was an immediate increase in the amount of drainage from the wound, which lasted for several days; the penicillin therapy was continued and supplemented by daily administration of streptomycin. He was again placed on tube feeding to improve his general nutrition, and by February 11 he was sufficiently well along in his convalescence to be allowed use of a wheel chair. Knee motion and daily physical therapy for the remaining uninjured portions of his body were instituted. The soft-tissue wound on the lateral posterior aspect of the thigh had filled in considerably (Fig. 6-C). The lateral wound through which the femur had been approached had healed completely; the granulating wound on the anterior side had long since closed. Roentgenographic examination on February 12 showed evidence of progressive bridging, particularly anteriorly, but there were multiple detached and semidetached fracture fragments, with some metal remaining around the fracture site. These fragments were considered to be a cause of the persistent drainage, and on February 19, the fracture site was again explored.

At the second sequestrectomy, on February 19, additional sequestrated bone fragments were removed. The intramedullary nail was inspected and showed no gross inflammatory reaction which could be attributed to the nail. The bone adjacent to the nail appeared to be no more involved than that in other portions exposed in the wound. Again the wound was packed open with fine mesh gauze and irrigation was reinstituted. By April 3, considerably more granulation tissue had developed. The nail and femur were covered so that they could no longer be seen in the depths of the wound. There was persistent drainage, but it was minimal as compared with that previously present. It had little or no odor, and the culture was sterile. For many weeks the patient had been free of pain requiring sedative medication. On April 3, 1951, he was transferred to San Diego, California, at his own request, to be near his home. (It should be mentioned that this man had received 5,650 cubic centimeters of blood while he was in the Hospital.)

Commander Landis Bell, Naval Medical Corps, stated that he had examined the patient on September 10, 1951. The wound had closed down to a small sinus which was persistently draining, the drainage being odorless but still purulent in character. At this time his hip motion consisted of approximately 20 degrees of flexion, with negligible abduction, adduction, and internal-external rotation. Knee motion was markedly restricted, from 180 degrees to approximately 165 degrees. The nail was still *in situ* and had not bent, considerable bone formation had occurred (Fig. 6-D), but clinical solidity could not be definitely determined because of the high location of the fracture. No additional bone had been placed about the fracture at any time. The patient was bearing slight weight on crutches.

In this instance, it seems safe to say that in nine months considerable new bone had developed, perhaps as an involucrum, around the pin, and that apparently a weight-bearing femur may be developing in spite of the osteomyelitis which he undoubtedly has. It appeared to us that his life was happier during these intervening months than it would have been with an unstable, painful lower extremity, narcotic addiction, and confinement in a cast or to his bed.

CASE 7. J. F. T., a twenty-year-old Private First Class, was admitted to the Oakland Naval Hospital on December 19, 1950. He had been wounded in Korea on December 7, receiving wounds in the right thigh and right calf and a fracture of the right femur. The calf wound had been superficial and did not involve the underlying bone. The wound in the right thigh over the fracture site left a defect measuring ten by five centimeters in the skin, subcutaneous tissues, and muscles. The patient was placed in a hip spica for evacuation and was removed to the United States by air. Upon admission he presented a one-centimeter crusted healing wound on the dorsum of the left hand. There was a flesh wound, granulating cleanly on the posterior side of the right calf. On the right thigh there was a defect measuring three by five centimeters in the soft tissues on the posteromedial aspect and a defect measuring ten by seven centimeters on the posterolateral aspect (Fig. 7-A). Roentgenograms showed a comminuted fracture of the mid-shaft, chiefly of the spiral type, involving the shaft over a distance of about twelve centimeters; there was medial angulation at the fracture site, the angulation being rather marked. Metallic fragments were noted adjacent to the fracture site.

An intramedullary nail was inserted retrograde on December 29 through the soft-tissue defect. A large detached fragment of bone was removed. This wound was packed open with fine mesh gauze and a catheter was left in its depths for irrigation. The postoperative course was quite uncomplicated; the wound had healed by February 28. There had been some roentgenographic evidence of the formation of provisional callus as early as January 19, 1951. Scant drainage from the operative wound was present on February 2. He was allowed up on crutches and was started on physical therapy to gain motion of the right knee. Measuring the extremities on February 15, we recorded the fact that he had two centimeters of shortening in the right lower extremity. He was placed in an ischial weight-bearing brace and was allowed to bear weight on the brace. In May 1951, callus was bridging across the shaft posteriorly for about one-half the diameter of the shaft (Fig. 7-B). He was wearing the brace when he was transferred to the Naval Hospital, Philadelphia, on May 8, 1951. It was our expectation at the time we discharged this patient that he would have to undergo additional reparative bone surgery at some time in the future. On July 23, 1951, after removal of the nail, the femur was healed fairly solidly, although a defect had remained in the central portion of the surrounding callus. Commander Wiggins wrote in December that all wounds had remained closed.

When last heard from, the patient had shortening of the right lower extremity of one-quarter inch, atrophy of the right thigh of three-quarters of an inch, no angulation, and full hip motion. Active knee extension was to 160 degrees and passive knee extension to 180 degrees, with knee flexion to 80 degrees. He was walking without a limp.

CONCLUSIONS

The authors have presented a group of compound fractures of the femur due to gunshot wounds, which they have stabilized by intramedullary fixation. These were a small portion of the scores of such injuries which came under our care or observation during the first six months of the Korean conflict. To our knowledge many more operations of this type have been performed, but at this time it is not possible to correlate the combined experience of those engaged in using this technique.

In our series we have had no catastrophes, no major loss of limb, and no deaths which could be attributed to the technique. In fact, none of the patients in whom we have used the pin has as yet succumbed from any cause.

It is the authors' opinion that, if such a technique is to be used, all the basic principles of modern war surgery must be carefully adhered to. Sufficient initial débridement, good after-care, and the proper selection of the time interval for internal fixation will determine the outcome.

Intramedullary stabilization by itself cannot overcome infection in bone. However, immobilization of the fracture permits the return of bodily vigor and mental health and prevents complete disuse and atrophy of the limb. As a result, it enhances the healing of bone in the presence of infection.

The authors are of the opinion that, if these wounds have not healed prior to surgery, they should be left open and treated as open infected wounds. The presence of the metallic nail does not retard this healing but hastens it; the nail, therefore, should not be removed during the healing process unless it is clearly evident that it is poorly placed mechanically and is contributing to the persistence of the infection. This has not occurred in any cases observed by us.

With proper selection of cases, adequate armamentarium, and properly trained surgeons, this technique is feasible, and when compared with alternatives is safe.

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DISCUSSION

Problems with Trauma to the Hand

(Continued from page 140)

mattress suture of fine silk on either side will suffice. The hand is then immobilized so that there is a minimum of tension on the sutured tendon ends.

I would be reluctant to consider the use of a tendon graft immediately after division of the flexor tendons within the digital sheath. If one feels that, because of the time that has elapsed, it is inadvisable to carry out immediate repair of the divided tendons, one can cleanse and close the wound; and within three or four weeks' time, one can carry out operation under the most favorable conditions. On the other hand, if we err in our judgment as to the possibility of converting the wound into a clean wound and carry out a tendon-grafting procedure immediately and if infection then supervenes, we practically burn all our bridges behind us.

One patient who sustained injury to the flexor tendons within the digital sheath came to us some sixteen hours after injury. We felt that because of the elapsed time we should not attempt primary repair. The cleansed and sutured wound healed by primary union. The patient entered the hospital six weeks after the injury, and a tendon graft was used to unite the distal phalanx with the flexor profundus in the palm. She has complete flexion at both interphalangeal joints.

Dr. Vinton E. Siler, Cincinnati, Ohio: In general, I would concur with Dr. Flynn's ideas. Dr. Flynn has re-emphasized the importance of considering the history and physical examination in deciding upon the course of treatment. At the Cincinnati General Hospital the time limit for primary surgical repair of divided nerves and tendons in the hand has not been extended beyond ten hours. Frequently the time interval from injury to primary surgical treatment has been seven or eight hours. Six hours is still considered to be the extended safe time for primary surgical repair, even with the aid of antibacterial therapy. We have been influenced by the appearance of suppuration in some of the primary operative cases after antibacterial therapy was stopped. In one patient, in whom there had been division of all flexor tendons, the ulnar artery, and the ulnar and median nerves at the wrist, primary repair was done seven hours after injury. Chemo-

(Continued on page 251)

COMPRESSION ARTHRODESIS OF THE KNEE

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From the Long Island College Hospital, Brooklyn

Compression arthrodesis of the knee is not presented as a new plan or as an original concept; it is presented as a method of intra-articular arthrodesis with extra-articular fixation, which can be used in spite of the presence of gross infection in the joint. The use of compression arthrodesis was first described by J. Albert Key in 1932[5]. It consisted in the excision of the knee joint by transverse and parallel saw cuts, and the fixation by compression of the cut bone surfaces by means of two horizontal and parallel Steinmann pins which were placed at right angles to the bone, one in the proximal end of the tibia and one in the distal end of the femur. The projecting ends of the pins were connected by screw clamps and wing nuts which were tightened until the nails bowed under the compressing force. The entire limb and compression apparatus was encased in a plaster-of-Paris cast and was so maintained for periods ranging up to six weeks.

Apparently, Key's enthusiasm toward the method waned, for in 1937 he described another method[6] in which a tibial peg was placed across the arthrodesis site, without any compression being used.

In 1948, Charnley described fifteen cases in which Key's method was used. He, however, eliminated the use of the initial cast and substituted a Thomas splint which supported the foot and the compression apparatus and maintained the 5 degrees of flexion at the knee which he felt to be proper. He thought that greater stability and comfort were made possible in this way, and he enthusiastically stated that "the method is superior to any other".

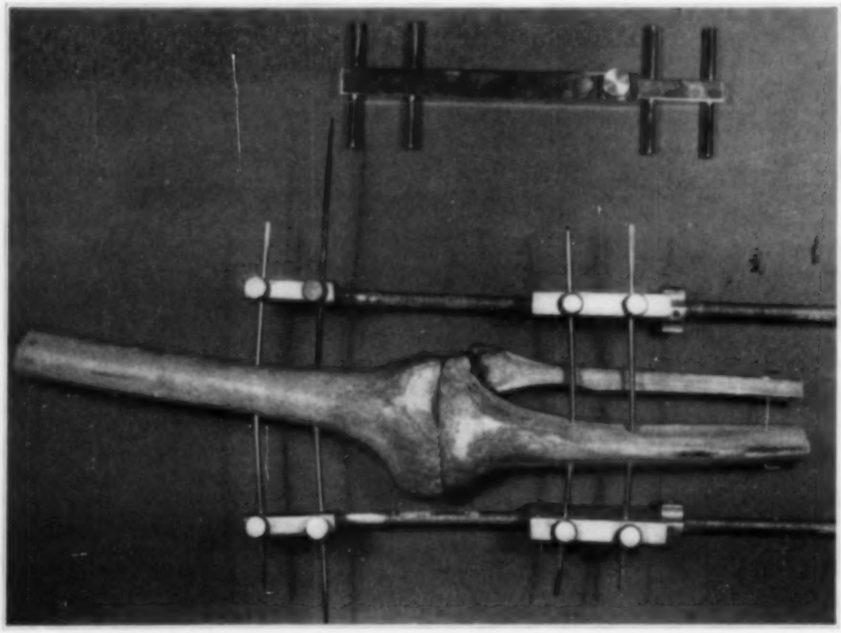

Fig. 1

Photograph shows apparatus applied to skeleton. The pins are bowed to the desired degree by the compression force.

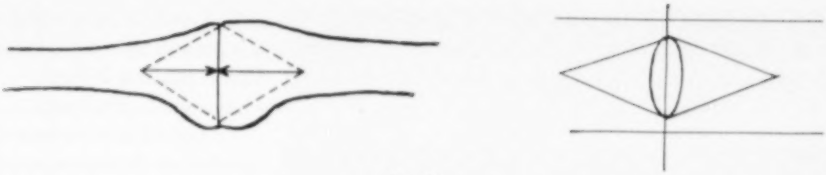

FIG. 2

Schematic drawing of compression by means of the two-pin method demonstrates the best possible application of the compression force. The conical force is in a maximum position of stability.

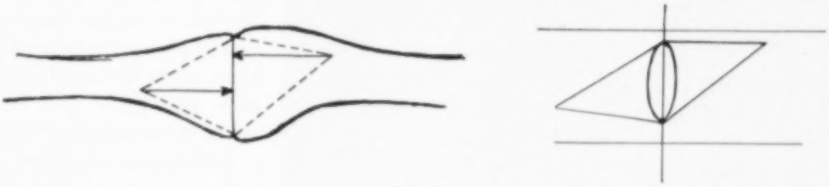

FIG. 3

Schematic representation shows the result of placing pins in an eccentric position. The resultant vectors actually lead to the disturbance of kinetic stability. The conical force is extremely unstable.

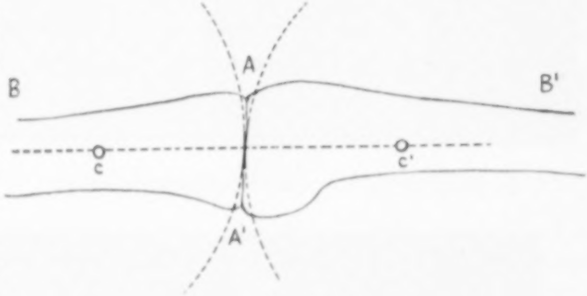

FIG. 4

Fig. 4: Distracting force may be applied at A, A^1, B, or B^1. This may produce motion at C or C^1, the position of the pins in the two-pin method.

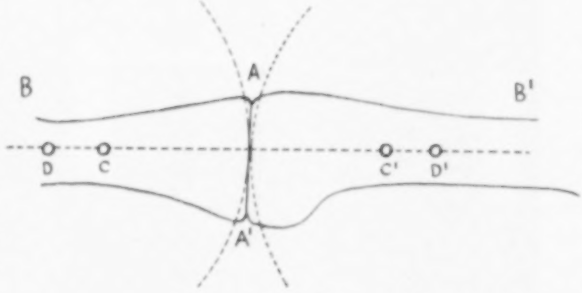

FIG. 5

Fig. 5: Distracting force applied at A, A^1, B, or B^1 cannot produce motion at C or C^1 or at D or D^1 because of the counter rotational force at the adjacent pins.

All of the operations resulted successfully in spite of four instances of mechanical postoperative failure which was due to the breaking of the pins. These incidents occurred in nine days, fourteen days, and at some indeterminate period before the end of six weeks after the operation. In the patient in whom the pin broke in nine days, firm clinical union was found when he was returned to the operating room on the twelfth postoperative day for the insertion of a new pin. The compression apparatus was removed and a plaster-of-Paris cast was substituted. Charnley thought that osseous union could not have occurred in this short time, and that only osteoid tissue cemented the bone ends together. Ultimately, a standard routine of compression for four weeks, immobilization in plaster with weight-bearing for four weeks, and rehabilitation without splinting for four weeks was adopted.

In his article, Charnley formulated a theory which stated that the trabeculae of the cut bone ends interdigitate and that osteoclasis occurs at the sites of maximum compression while osteogenesis occurs in the adjacent areas. The bony substance produced by the compression destruction is made immediately available to the blending osteoid tissue which is produced by the osteoblasts of the opposing ends of the bones, each of which contributes to osteogenesis and ultimate healing. This process is known as "local transference". This theory has been substantiated by Ely and by Ainsworth and Wright.

In this series, a total of nine compression arthrodeses have been performed. The first was done after the failure of fusion in a patient with tuberculosis of the knee in whom a modified Albee type of procedure had been employed in which the patella was used as an inlay graft and bone chips obtained near by were placed in and around the arthrodesis site.

The next two were done by the use of the original Key method; in the second of these, the apparatus was removed at fourteen days because of local infection at the pin sites. The operative note states that the knee was clinically firm when the compression apparatus was removed.

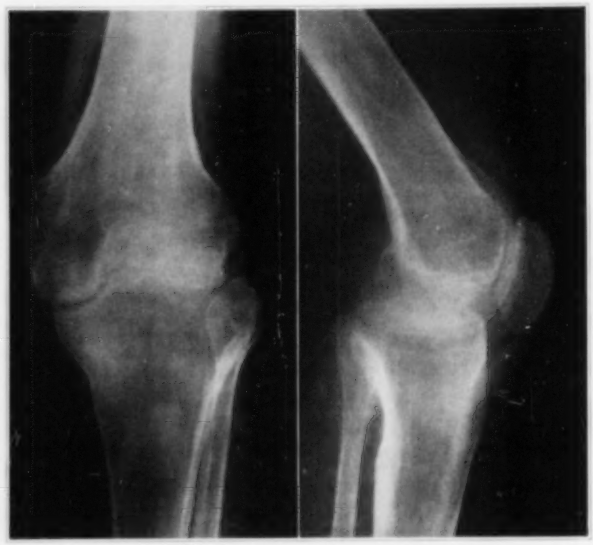

Fig. 6-A

Preoperative films show active tuberculosis of the knee.

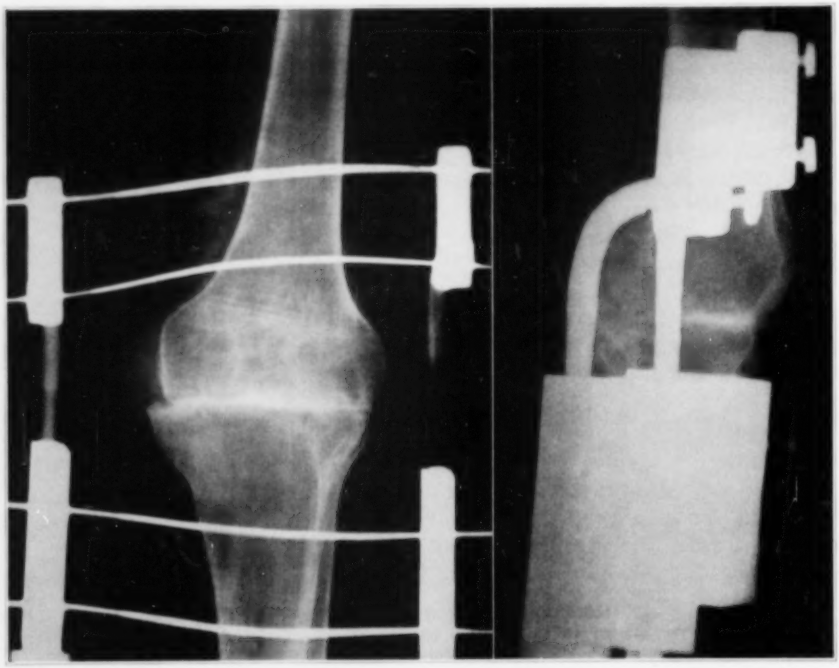

Fig. 6-B

Same patient, one day after the operation with apparatus in place and compression force applied.

In the fourth, Charnley's modification was employed and a satisfactory end result was obtained. The apparatus was removed on the sixteenth postoperative day; the arthrodesis was noted to be solid.

The fifth was a failure. The patient was irrational and completely uncooperative for several weeks postoperatively, and all approximation was lost.

In this case it is felt that the compression force was altered in the postoperative state in such a way that compression destruction was produced in the posterior aspect of the femoral cortex which actually abetted instability and aided in the failure of the procedure.

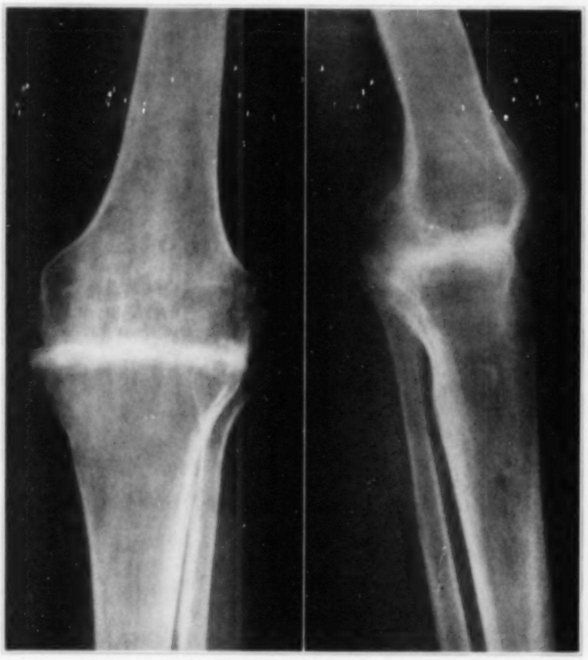
FIG. 6-C

Same patient, sixteen weeks postoperative, after the removal of compression apparatus.

It was felt that some modification of the compression apparatus could be made in order to improve positive fixation. The horizontal stability in Key's method and in Charnley's method was most satisfactory, but with a little force, anteroposterior motion could occur which would produce angulation at the arthrodesis site. A method of inserting additional pins was sought, and it was decided that two pins on each side of the arthrodesis site would provide a much more solid fixation than one. The relative plane of insertion of the pins seemed not to be important as long as they could be rigidly maintained in the desired position. Plans were therefore drawn for an apparatus which was strikingly similar to the one described by Abbott[7] for use in bone-lengthening procedures. The guide was used for the spacing and inserting of the Steinmann pins in a single parallel plane, two above and two below the joint. A simple change of the nut which had controlled lengthening to the opposite side of the sliding block would easily bring about an extremely solid compression (Fig. 1). The use of both the cast and the Thomas splint has been eliminated and the use of a small pillow beneath the knee in order to maintain slight flexion at the knee (5 to 10 degrees) is advised. Charnley's routine of four weeks of compression, four weeks in a cast, and four weeks of rehabilitation was followed. This program was employed in the remaining cases in this series and in each instance the absence of discomfort, the rapidity of convalescence, the solidity of union, and the satisfaction of the patient have been most gratifying.

DISCUSSION

Key's method, together with Charnley's modification of it, employs the principle of two cones, placed base to base, to develop and maintain internal stability during the process of compression arthrodesis (Fig. 2). Only if the pins are placed exactly in the center of the shafts of the involved bones, will the compression forces be exerted in an equicentric manner. Off-center positioning will cause unbalanced compression (Fig. 3).

When an anteroposterior displacing force is applied, the pin site becomes the axis

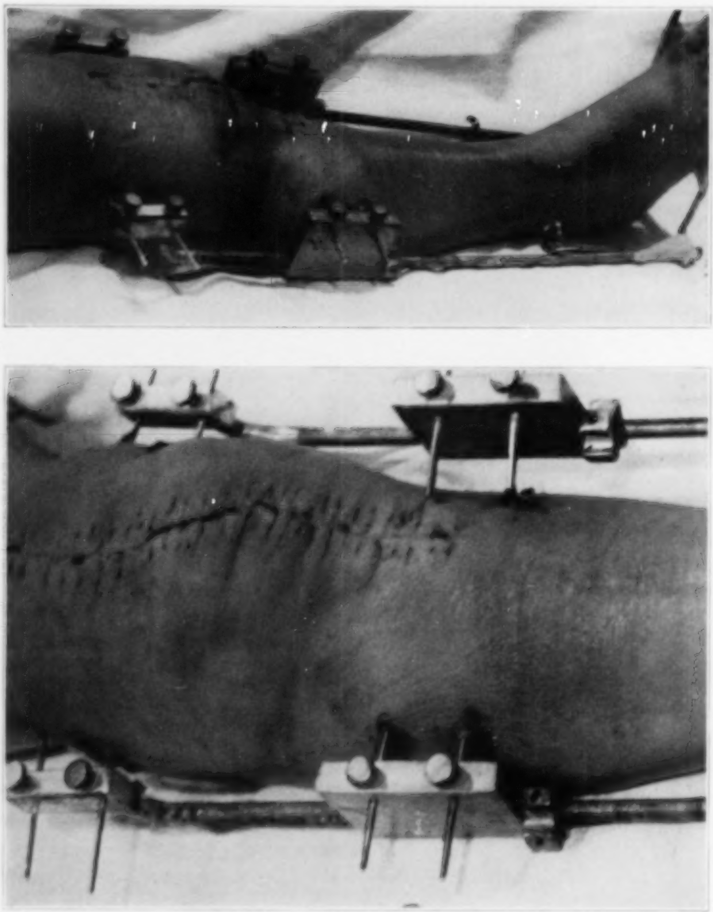

FIG. 6-D

Photographs showing apparatus in place, ten days after the operation.

of a fulcrum about which rotation of the bone can occur; distraction is produced at the compression surfaces, and thereby the desired effect of continuous, undisturbed maintenance of position at the site of the arthrodesis is terminated (Fig. 4). In the suggested modification, the pins may also be considered individually as an axis or center of rotation, but when applied as a part of a rigid unit, each has a tendency to counteract the rotatory motion of the other (Fig. 5).

All of the compression force which is attained by Key's method is preserved, but any need for the bone ends to provide internal stability until union occurs is eliminated. The four pins are firmly attached to the compression apparatus by thumb screws; thus the apparatus can in no way rotate about the pins. Before compression force is exerted, motion at the joint can only be made in two directions, namely, toward or away from the joint. Anteroposterior and lateral motion is eliminated the moment the thumb screws are tightened (Figs. 6-A through 6-D). This has been demonstrated with the use of models and on a patient. When the compression force is applied, the only possible effect is to force the bone ends together and to maintain them in that position alone. In effect, this produces the same contact compression as that obtained by the use of the internal contact splint described by Eggers or an intramedullary nail in the treatment of fractures of the long bones.

The method has the additional merit that thinner and more flexible pins may be used. There is, thus, practically no likelihood that Charnley's mechanical failure (fracture of the wires) would occur.

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TENDINITIS OF THE INSERTION OF THE COMMON EXTENSOR TENDON OF THE FINGERS

BY MICHAEL BURMAN, M.D., NEW YORK, N. Y.

The usual expression of recurrent occupational strain of a finger is tendovaginitis (often stenosing) rather than tendinitis. Tendinitis of the common extensor tendon of a finger, induced by habitual use of the finger, has to the author's knowledge not been previously described.

Case 1. A right-handed woman, thirty-two years old, consulted the author on May 14, 1951, at the request of Dr. Jerome Weiss. She had complained of pain in the right ring finger for a year. She was a talented pianist who practised at least six hours each evening. Her pain was induced when she bent the finger in touching the keys of the piano. She could not lift the finger from the keys as well as she had been able to do formerly. She had the unusual habit of pressing the ulnar side of the ring finger against a table or against the piano as she spread the ring and little fingers apart; she had done this for seventeen years. A year ago, when the finger became painful, she discovered a small, tender nodule on the dorso-ulnar side of the head of the first phalanx of the finger. She believed that the mass had been growing in the past three months.

The small, pea-sized and tender nodule, found in the location given, was apparently attached to or was part of the common extensor tendon of this finger. The mass was firm and had little mobility. The skin over the tumor was reddish, but sometimes it was blue. The proximal joint could be actively straightened to 180 degrees, but its flexion was painful; the angle of greatest flexion was 80 degrees. The roentgenogram of the finger was negative. The diagnosis was uncertain, the discreteness of the tumor and discoloration of the skin suggesting angioma.

The finger was explored on May 21, 1951, under digital nerve-block anaesthesia and with the use of a wide rubber band at the base of the finger to act as a tourniquet. No mass was found when the extensor apparatus was stripped from the dorsum of the proximal interphalangeal joint. The substance of the insertion of the common extensor tendon was thickened. A very friable, reddish tissue, looking like granulation tissue, was found beneath the most distal part of the common extensor tendon in the interval between tendon and bone. The joint cartilage was normal in the exposed dorsal part of the joint. This friable tissue, together with a small longitudinal wedge of the tendon, was excised. Sections of the tendinous tissue showed thickened and vascularized connective tissue.

The wound healed well. The patient had no complaints on August 22, 1951. She had returned to her piano practice but played for a shorter time each day. The grip on the right measured by the hand grip was sixty-eight pounds, on the left seventy pounds. The circumference of the proximal joint of the finger subjected to operation was two and a quarter inches, that of its mate in the left hand two inches. Flexion and extension of the finger were full and painless. No mass was felt, except for a tiny lump just radial to the distal end of the scar. This was a granuloma about one of the silk sutures used to close the dorsal aponeurosis.

Case 2. A woman, thirty-three years old, presented herself on April 8, 1952, with a similar swelling, confined to the dorso-ulnar side of the proximal joint of the right middle finger, and noted for a few months. She played both the piano and the accordion, the latter being played with the forearm supinated and the wrist volarly flexed.

CASE 3. A woman, eighteen years old, consulted the author on May 12, 1952, at the request of Dr. Frank Serafin. Her work for a theater-ticket company required her to place rubber bands about bundles of tickets, each bundle being about one-half to one inch thick. She had done this several hundred times a day for a month. The tickets were held with the left hand and the rubber band was passed about the bundle of tickets with the right hand, as any right-handed person would do. About March 7, 1952, she began to have pain and swelling in the hand along the course of the common extensor tendon to the right middle finger. Later the dorsal aspect of the proximal joints of the right index and middle fingers became painful and swollen after the swelling in the hand itself had subsided. The hand was splinted and she was given physical therapy.

Discrete swelling and tenderness localized on the dorsal and ulnar side of the insertion of the common extensor tendon of the right index and middle fingers were seen. The proximal joint of each finger was itself normal and there was no sign of rheumatoid arthritis in any of the fingers. Extension of each proximal interphalangeal joint was 180 degrees. Flexion, however, was painful and was restricted to 90 degrees in the affected fingers. The tips of these fingers did not touch the palm as she made a fist. The thumb, little and ring fingers, and the wrist were normal. The roentgenogram of the hand disclosed slight osteoporosis, but no evidence of intrinsic pathological changes in the bones or joints of the hand. Rest and whirlpool baths were advised.

COMMENT

The genesis of the malady is the forced or repeated flexion of the proximal interphalangeal joint against maintained extension of the finger at the metacarpophalangeal joint or extension of the metacarpophalangeal joint in maintained flexion of the interphalangeal joints. The irritation caused by stretching of the common extensor tendon is confined to the dorso-ulnar side of the common extensor tendon of any of the fingers of the dominant (right) hand. The thumb has been excepted in the cases seen. Flexion of the proximal joint is actively restricted by stretch of the painful tendon.

This genesis of the malady was quite clearly seen in Case 3. The rubber bands flexed the proximal joints of the index and middle fingers in maintained extension of the metacarpophalangeal joints. The unaffected thumb was held extended at both the metacarpophalangeal and interphalangeal joints. The comparable extension of the ring finger in Case 1, lifted away from the key it had just struck, a movement repeated many hundreds of times, did the same thing, for the metacarpophalangeal joint remained extended and the proximal joint remained flexed.

The broadening of the spread of the ring finger is the concern of every pianist. Some have sectioned the tendinous band which joins the middle and ring fingers or the ring and little fingers in the effort to get more spread. The patient in Case 1 had tried to achieve the same purpose by the exercise she dubbed a habit. In doing so, she often pressed upon the spot which later became painful and swollen. It is possible that this factor also played a part in the perpetuation of the tendinitis.

In Case 2 there was strain of the common extensor tendon in the flexed position of the wrist, as the finger was bent at its proximal joint. The flexion of the finger while the wrist is in this position evokes strain of the common extensor tendon of the finger even in the normal hand.

The differential diagnosis must rule out rheumatoid arthritis or tumor of the finger near the tendinous insertion. If the conservative measures of rest, splinting, and physical therapy fail, operation for the purpose of releasing tension is indicated. The splitting of the tendon relieved tension within the tendon in the case in which operation was done.

CAPSULAR ARTHROPLASTY FOR CONGENITAL DISLOCATION OF THE HIP

A Two-Stage Procedure*

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From the University of Pennsylvania, Philadelphia

The choice of treatment in congenital dislocation of the hip must be decided upon only after a number of factors have been considered. The age of the patient is one of the most important, although the degree of telescoping and the conformation of the osseous elements comprising the hip joint are basic considerations.

The purpose of this paper is to demonstrate one satisfactory method for treating congenital dislocation of the hip in children and to stress the indications, contra-indications, and complications of the method, based on over twenty years' experience with this two-stage procedure. It is not a procedure advocated for the treatment of hip dysplasias other than dislocations. The first patient was operated upon June 1, 1930, and the method was first described in *The Journal of Bone and Joint Surgery*, April 1932.

PROCEDURE ADVOCATED

In the safe reduction of any dislocation, adequate relaxation of the soft tissues about the joint must be obtained; this is particularly desirable in the congenitally dislocated hip.

In the method to be described, therefore, a preliminary closed *first stage* is necessary consisting of a subcutaneous adductor tenotomy and the stretching of the hamstrings, followed by the application of skin or skeletal traction to the dislocated side. The opposite side is routinely immobilized in a long plaster spica. This first stage must be continued until the head is pulled down opposite the level of the deficient acetabulum. Usually this requires two or three weeks, although the surgeon must not be guided by the calendar. Then, and only then, should the second stage or the open operation be done (Figs. 1-A, 1-B, and 1-C). The first stage is always employed unless there can be demonstrated by push-and-pull roentgenograms sufficient relaxation preoperatively.

This operation, the capsular arthroplasty, is prebicated upon the fact that the gliding mechanism between the displaced and dislocated articular femoral head and its encircling synovial-membrane-lined capsule can be retained when transplanted into a reconstructed acetabulum. By this means both stability and mobility can be ensured.

The operation differs fundamentally from the various buttressing or shelf operations in that there is a central replacement of the capsule-covered head into its exact anatomical position rather than the construction of a ledge or shelf over the laterally, and frequently posteriorly, displaced femoral head.

The *second stage* is done as follows: The hip joint is preferably exposed by means of the lateral approach. The incision begins a finger's breadth posterior to the anterior superior spine, curves downward, and crosses the shaft of the femur several inches below the tip of the greater trochanter. The investing fascia is divided, and the abductor muscles attached to the greater trochanter are exposed.

Only the tip of the greater trochanter is incised. The entire group of attached abductor muscles are then separated by scissor dissection from the underlying capsular tissue. The isthmus of the capsule is identified and is divided at its narrowest portion. The head of the femur is then inspected. The limb is gradually externally rotated and adducted,

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*Read at the Joint Meeting of the Orthopaedic Associations, London, July 3, 1952.

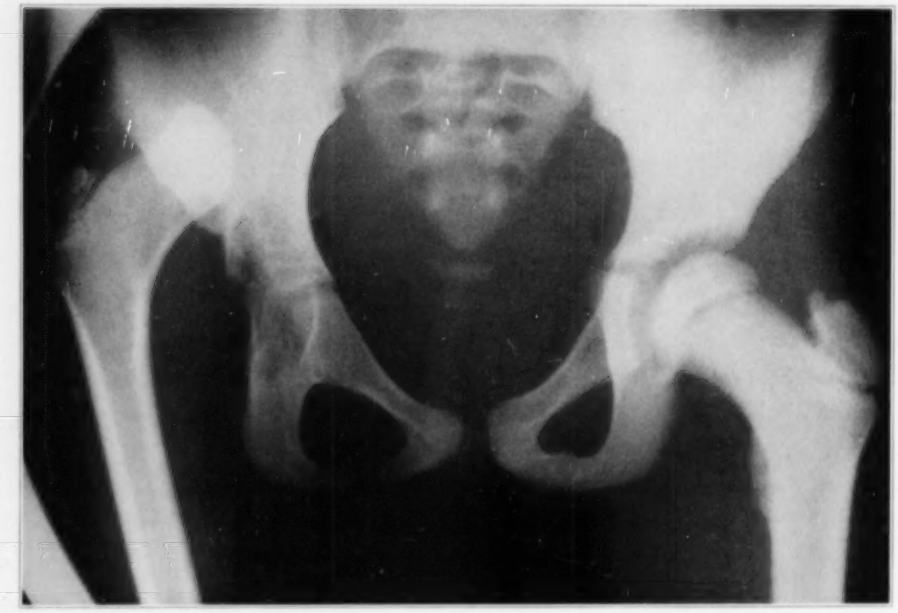

FIG. 1-A

G. S. Roentgenogram shows the position of the femoral head in a posterior congenital dislocation before treatment.

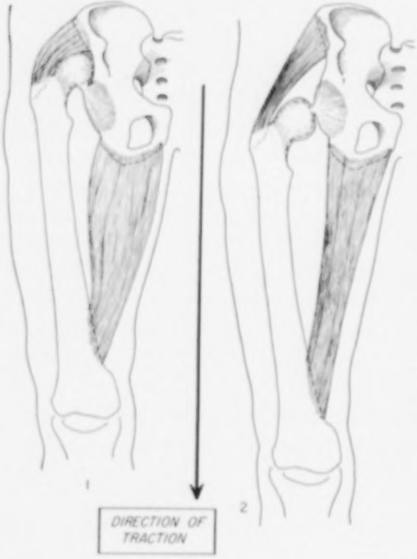

FIG. 1-B

Drawing diagrammatically shows the direction and effect of traction after the stretching of the hamstrings and the subcutaneous adductor tenotomy.

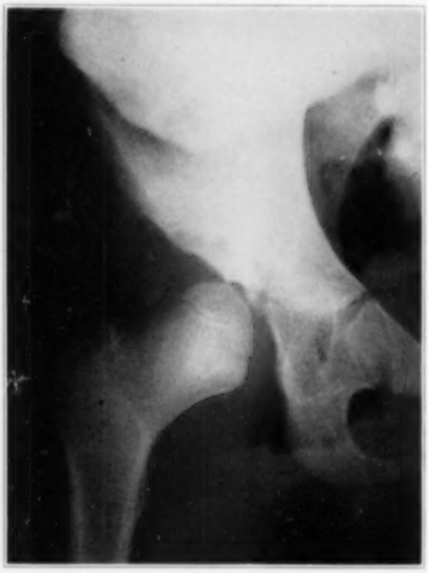

FIG. 1-C

Roentgenogram made at the end of the first stage indicates that the femoral head has been pulled down opposite the deficient acetabulum.

while the capsule, covering the head as a sac, is completely freed from the surrounding tissues. The ligamentum teres, if present, is excised close to the head. The opening in the *distal* portion of the capsule is closed by several interrupted catgut sutures. A complete capsular sac about the femoral head is thus produced. The proximal portion of the capsule

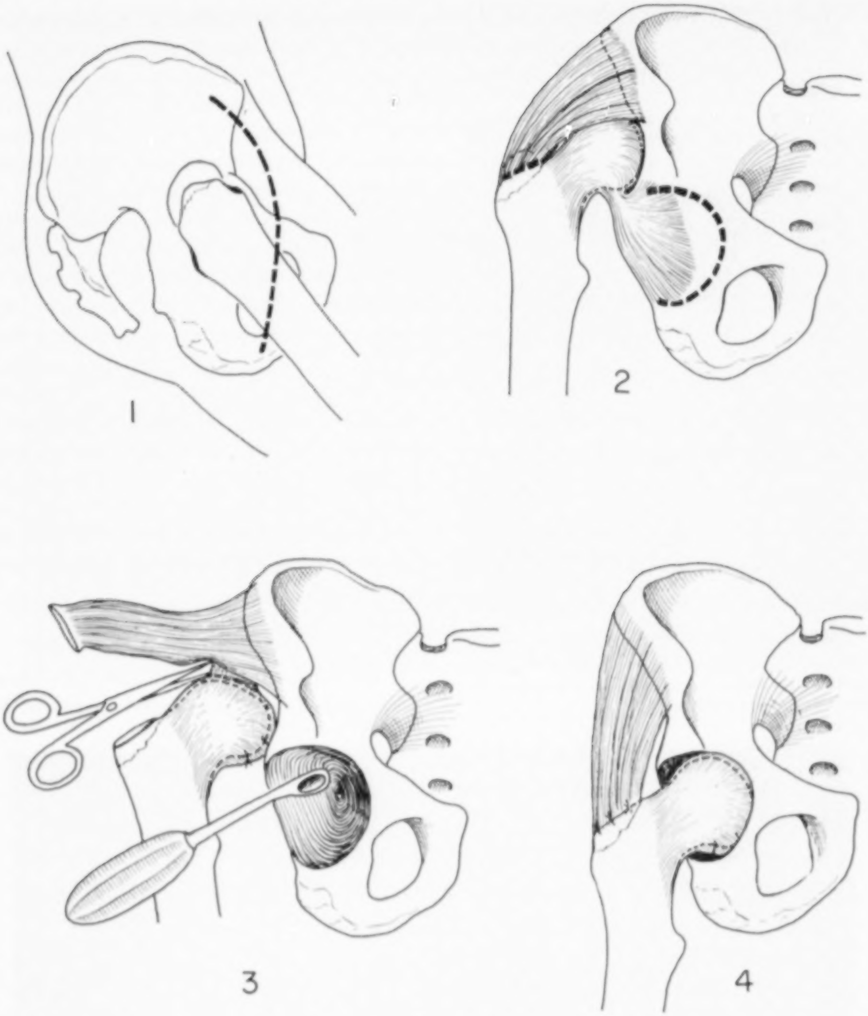

Fig. 2

Diagram shows the skin incision (*1*) and the steps in the second stage of the operation (*2*, *3*, and *4*). (By permission of *Surgery, Gynecology and Obstetrics.*)

which is attached to the rim of the rudimentary acetabulum is excised as completely as possible. With the limb still in external rotation and adduction, the site of the original hip socket is identified and outlined with a sharp scalpel. A large curette or a reamer is used to construct carefully a capacious, *cup-shaped cavity* at this level, care being taken not to injure the head or the capsular tissue covering the head. It is helpful to identify the triradiate cartilage in the floor of the reconstructed acetabulum in order to confirm its true site. The innominate bone at this level is very thick; and, when this procedure is done for the first time, the surgeon is always surprised at the amount of bone which may be safely removed. The floor of the entire socket must feel smooth to the palpating finger. *If the socket is made with too sloping walls*, it will not ensure future stability (Fig. 2 and Fig. 4).

No effort is ever made to reconstruct the femoral head or neck, however changed it may be from the normal. The head, with the surrounding capsular sac, is placed *deeply* within the newly made socket — a skid or force is never used. Sometimes excision of some of the redundant and thickened capsular tissue over the femoral head may have to be done in order to seat the head deeply; marked internal rotation is occasionally necessary in order to reduce the head securely. When this is necessary, a supracondylar osteotomy with derotation of the distal fragment should be done a few weeks later.

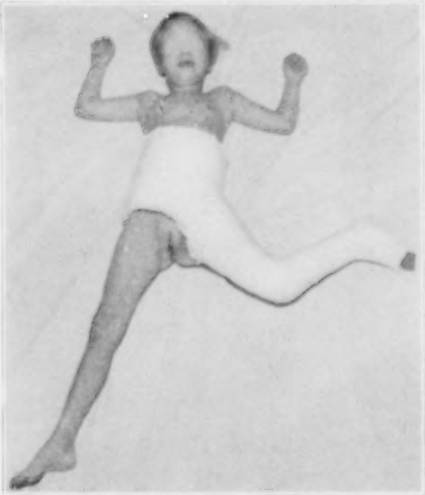

FIG. 3

Photograph shows the marked internal rotation which is occasionally desirable. A supracondylar osteotomy is done later.

No effort is made to suture or to attach the transposed capsular tissue to the acetabulum, for it is believed that the capsule becomes firmly attached to the raw bony walls of the newly made socket within a few weeks and that the head will then move within its synovial-membrane-lined wall. The greater trochanter and its attached muscles are replaced and are held in position with a number of catgut sutures rather than by metal fixation. The wound is closed in layers and a unilateral plaster spica is applied from the nipple to the toes with the limb in only moderate abduction.

POSTOPERATIVE CARE

The hip is usually taken out of the plaster at the end of four weeks and overhead bal-

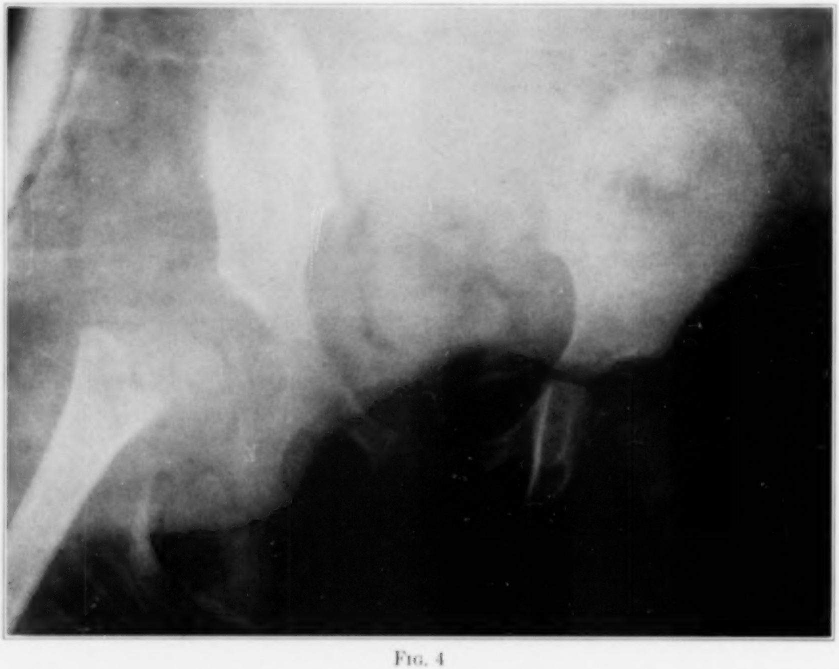

FIG. 4

Roentgenogram shows an inadequately reconstructed acetabulum. The inadequate depth and the saucer-like slope (rather than the cup-shaped acetabulum desired) of the reconstructed acetabulum can be clearly seen.

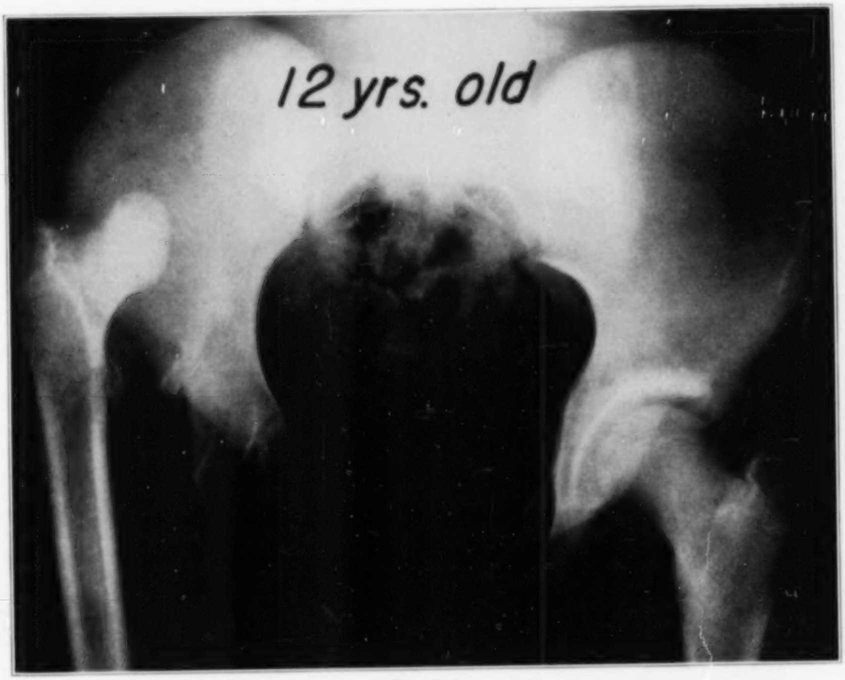

Fig. 5-A

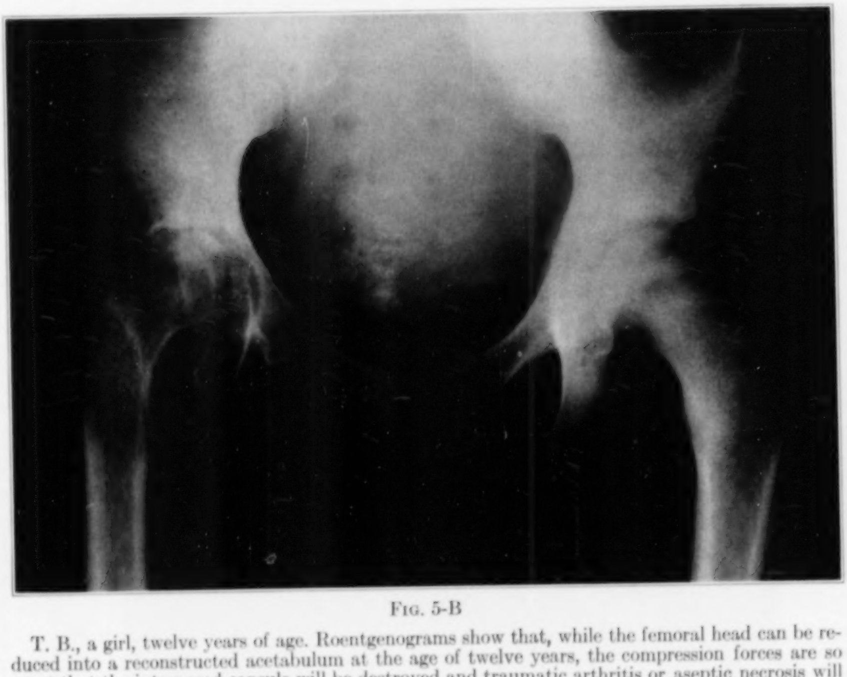

Fig. 5-B

T. B., a girl, twelve years of age. Roentgenograms show that, while the femoral head can be reduced into a reconstructed acetabulum at the age of twelve years, the compression forces are so great that the interposed capsule will be destroyed and traumatic arthritis or aseptic necrosis will result.

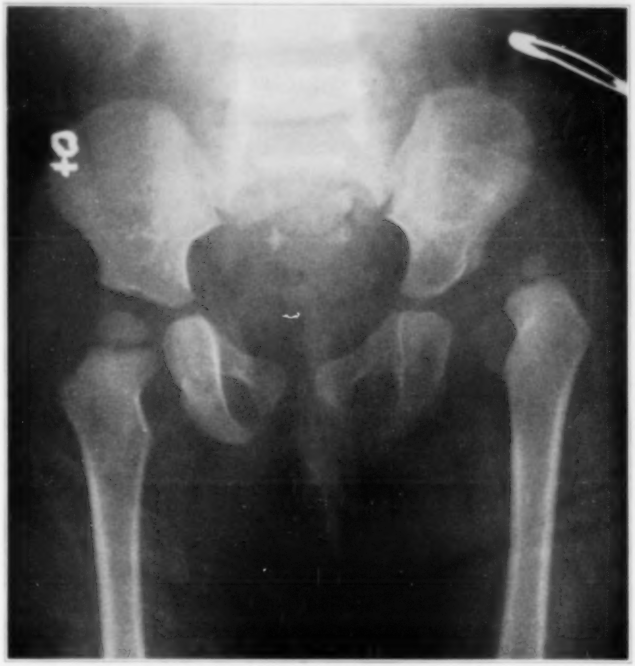

Fig. 6-A

F. K., a girl, sixteen months old. Roentgenogram shows the condition before operation.

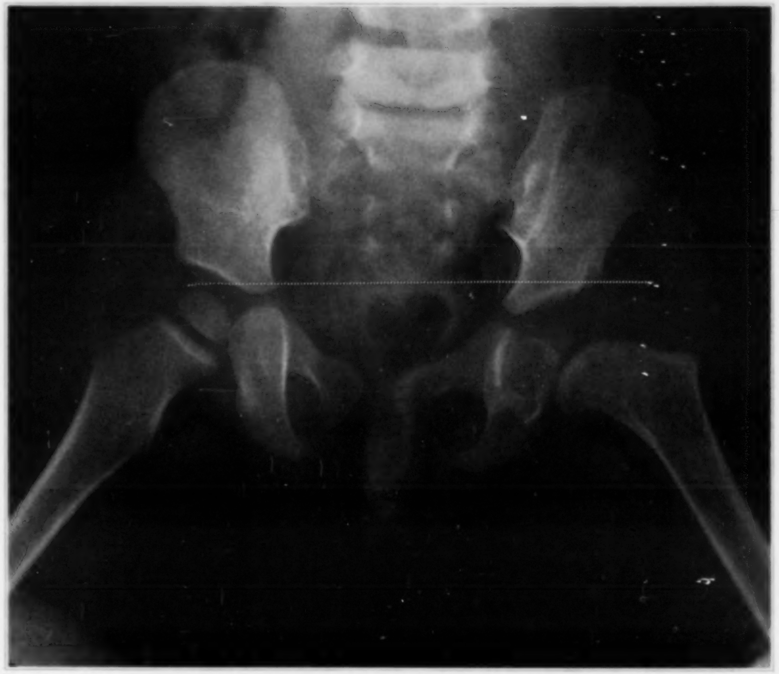

Fig. 6-B

Roentgenogram made four months after the operation.

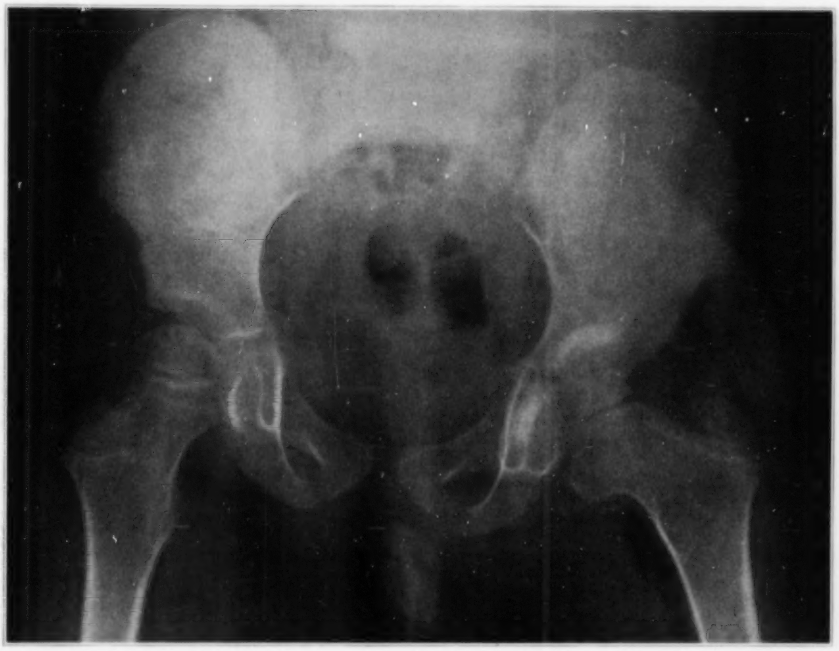

FIG. 6-C

Roentgenogram made two years later shows the development of the femoral head within the reconstructed acetabulum.

anced suspension is begun, the limb being kept in a little abduction by the simple expedient of placing a pillow or sand bag between the knees. Soon the patient can combine active movement in bed with exercises in the therapeutic tank, if one is available. Sitting up in bed a part of the day and lying on the abdomen a portion of the time is encouraged. The latter is important in order to prevent the development of hip-flexion contracture. Careful daily examination of the hip during this convalescent period must be done in order to detect muscle spasm early. Not until a good range of active and passive movement in bed can be demonstrated, should weight-bearing be permitted. It should be stated that a minimum of three months, and sometimes as much as six months, must elapse following the open operation before weight-bearing on the hip is permitted, even for limited periods. During this early weight-bearing stage any loss of hip motion must be followed by bed rest and the application of traction. Braces to protect the hip against weight-bearing have been little used, because children in this age period are rarely cooperative enough to be trusted on crutches.

INDICATIONS, CONTRA-INDICATIONS, AND COMPLICATIONS

Age

Under three years of age, the majority of congenitally dislocated hips can be reduced and the reduction can be maintained by closed methods of treatment. Failures in this age group are thought to be due to the occasional patient in whom closed reduction is not possible, or to the instance in which the surgeon does not properly interpret the post-reduction roentgenogram and believes that an adequate reduction has been obtained when it has not.

It is felt that at least 65 per cent. of bilateral and 75 per cent. of unilateral congenitally dislocated hips in patients under three years of age can be reduced and will remain reduced by closed reduction. This does leave a certain percentage of patients, how-

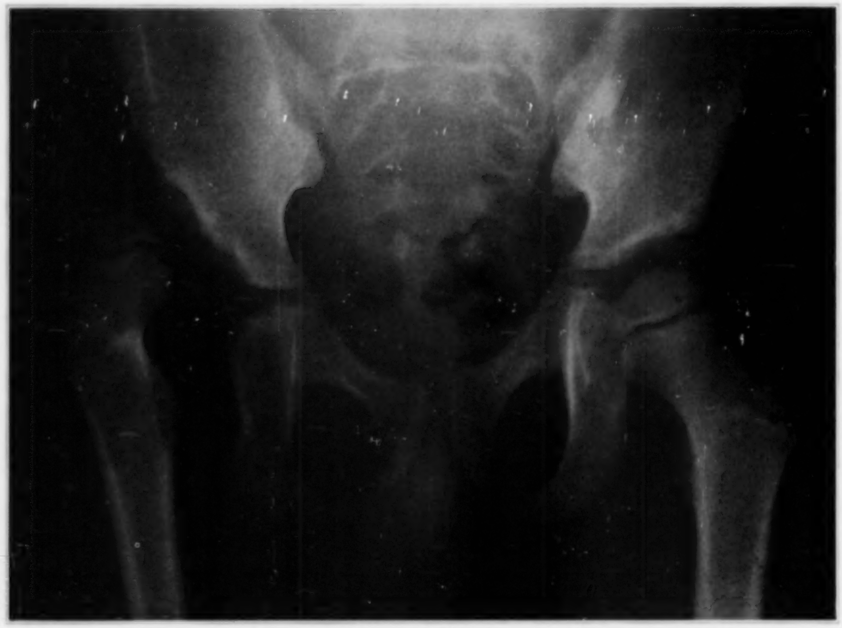

FIG. 7-A

B. H., a boy, five years old. Roentgenogram made October 24, 1947, before the operation.

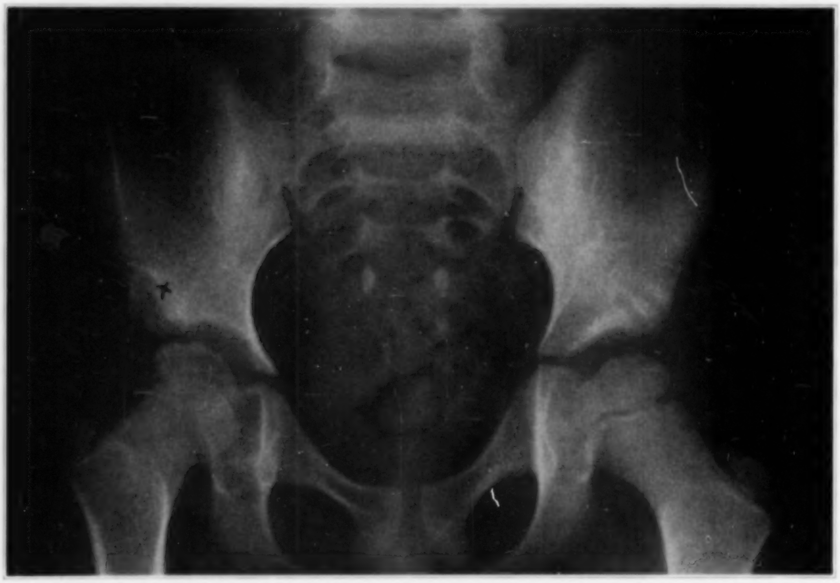

FIG. 7-B

Roentgenogram made October 27, 1948, one year later.

ever, in whom capsular arthroplasty should be seriously considered. We would like to state that we have only done the operation four times in patients under the age of two; and, as two of these later developed an avascular necrosis of the femoral head, we feel that the operation should be delayed until the child is over two years of age.

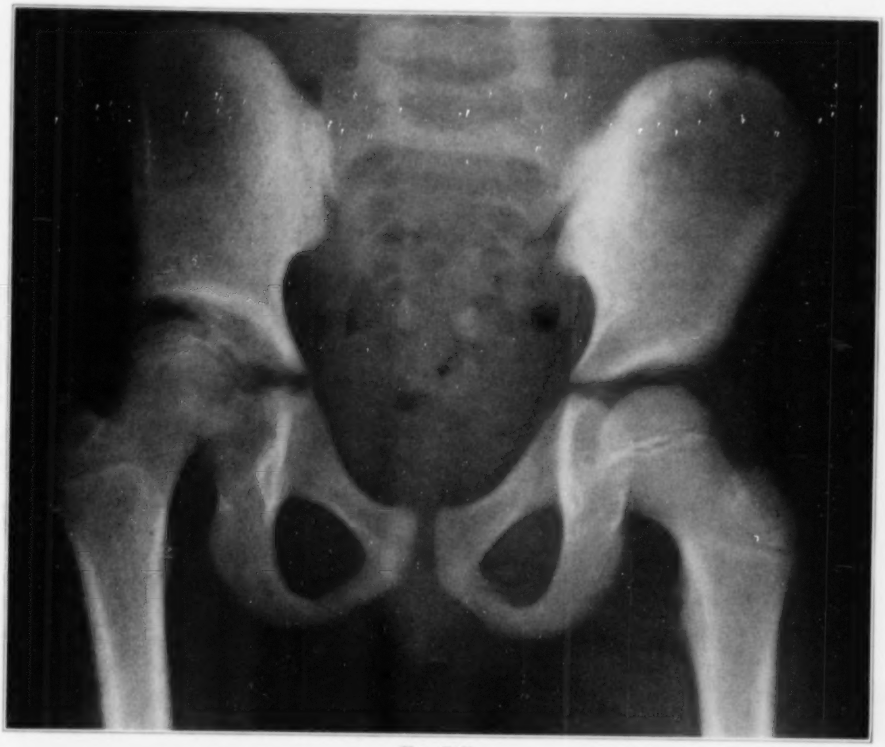

FIG. 7-C

Roentgenogram made five years after the operation. Note the development of a good lip to the acetabulum which occurred following the stresses and strains of normal weight-bearing.

The great majority of the operations which have been done in the past twenty years have been in patients over three years of age and under ten. Our review would indicate that the best results have been obtained in patients between the ages of three and six years for those involved bilaterally and between three and eight years for those involved unilaterally. It is difficult to limit the operation in children wholly on an age basis, for there are certain individual differences regarding osseous and soft-tissue abnormalities. On the basis of our experience, we do not at this time recommend the use of the capsular arthroplasty in children over the age of ten, for those with the unilateral dislocations (Figs. 5-A and 5-B), or over the age of eight for those with bilateral dislocation. When the patient has bilateral dislocation, a delay of *at least* six months between hip operations should be observed.

Bone tissue, within certain limits of stress and strain, is a malleable, accommodative substance; but articular cartilage and bone will always undergo aseptic necrosis when they are subjected to the continuous pressure produced against the reduced head in older children. Therefore, in children over ten some type of osteoplastic buttress is at present considered more desirable.

Stimulation of Epiphyseal Growth

In a few of the patients reviewed there has been some stimulation of epiphyseal growth—one having had overgrowth of as much as an inch. In this patient, an epiphyseodesis of the distal portion of the opposite femur gradually corrected the discrepancy. For those patients with less than one-half inch overgrowth, we are not concerned; but we do wonder what factors may be responsible for stimulating limb growth. It is recognized

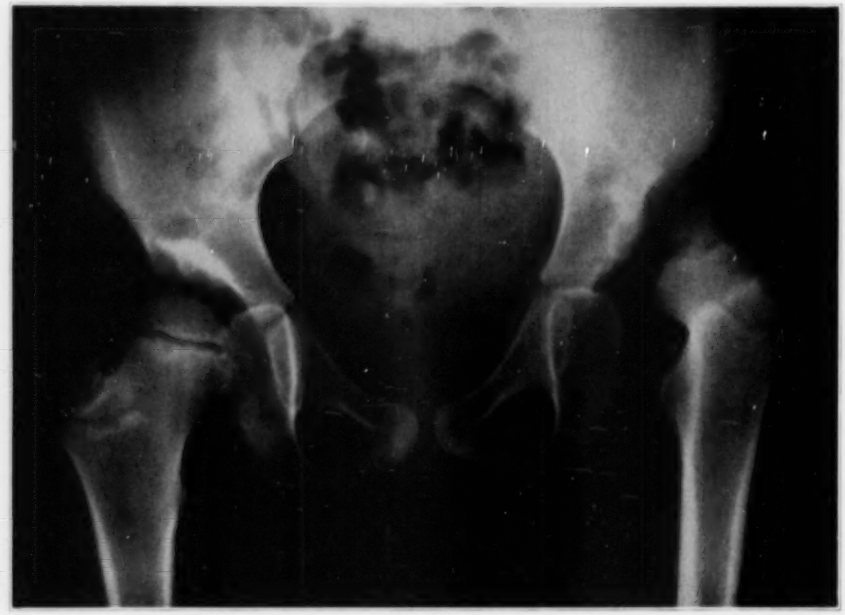

FIG. 8-A

P. M., a girl, four and a half years old. Roentgenogram made before the operation.

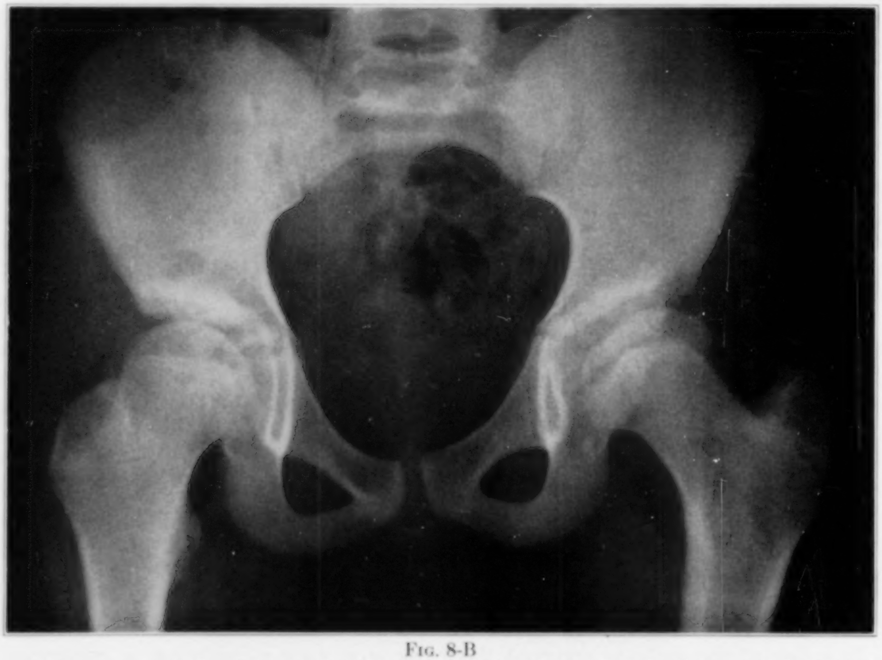

FIG. 8-B

Roentgenogram made eight years after the operation. Note the excellent development of the femoral epiphysis and neck after torsion had been corrected by supracondylar osteotomy.

that, in the majority of patients with congenital dislocation of the hip, the whole limb is slightly underdeveloped, so that a slight stimulation of growth could be desirable.

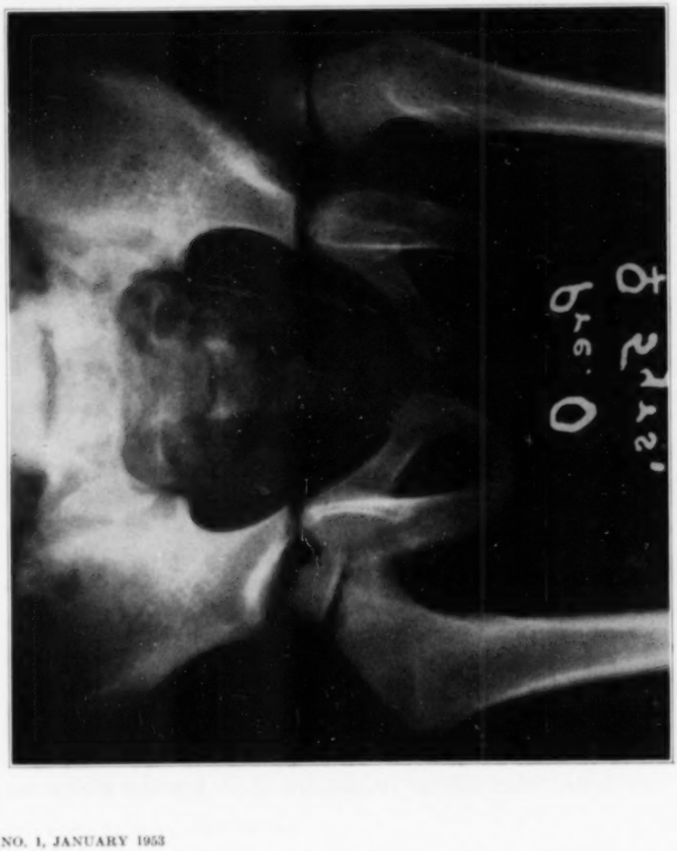

FIG. 9-A

V. H., a girl, five years old. Roentgenogram made before the operation.

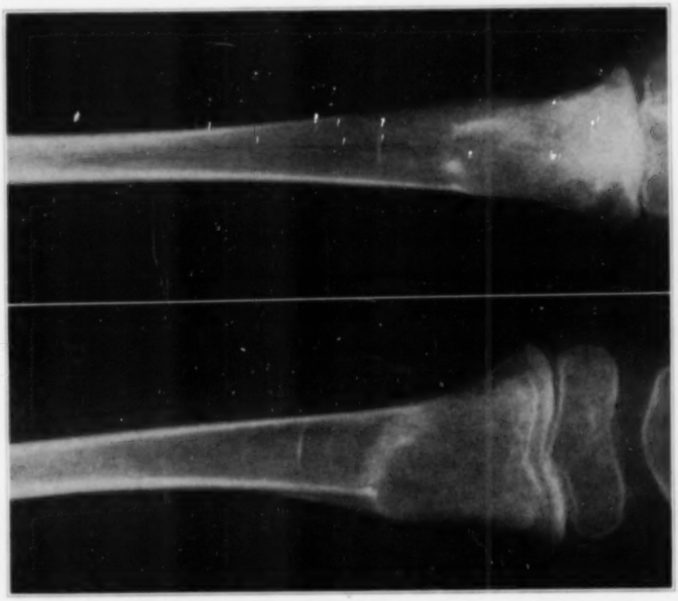

FIG. 9-B

Roentgenogram shows the healed supracondylar osteotomy.

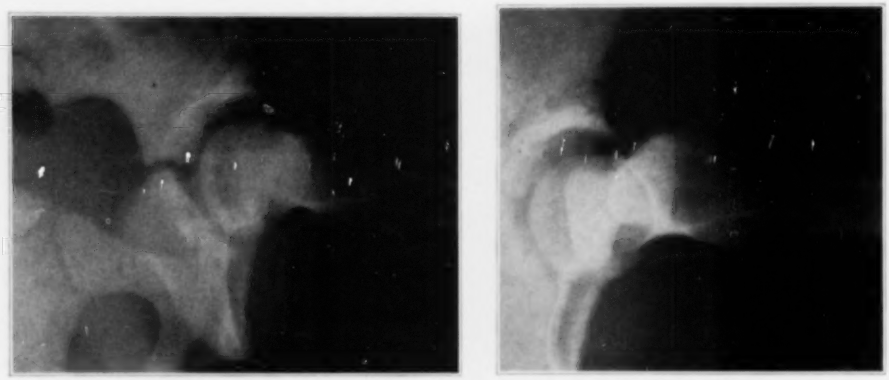

FIG. 9-C FIG. 9-D

Fig. 9-C: Lateral roentgenogram made one year after the operation shows the appearance of the hip joint.
Fig. 9-D: Lateral roentgenogram made seven years after the operation.

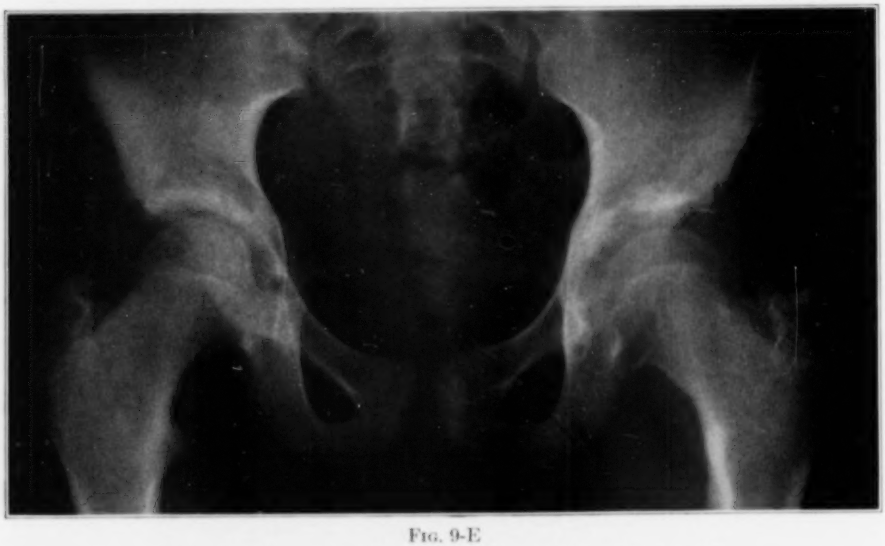

FIG. 9-E

Anteroposterior roentgenogram made nine years after the operation.

In a few of the patients with marked anteversion in whom a supracondylar osteotomy was done, there was noted some slight stimulation in growth. It is conceivable that the osteotomy might have been a factor in accelerating limb growth, even though acceleration of growth has not been noted in all of the patients who have had a supracondylar osteotomy.

We have noted growth of the greater trochanter following the operation. This we have attributed to the fact that our incision may have encroached upon the epiphyseal plate. Since we now remove only a small flake of cartilage when the abductor muscles are turned upward, we have not noticed this local growth stimulation.

Abductor Weakness

A negative Trendelenburg test has resulted in the great majority of patients, although not in all. The lateral approach, which we prefer, gives excellent exposure, and it is hard to see how it may offer damage to branches of the superior gluteal nerve more

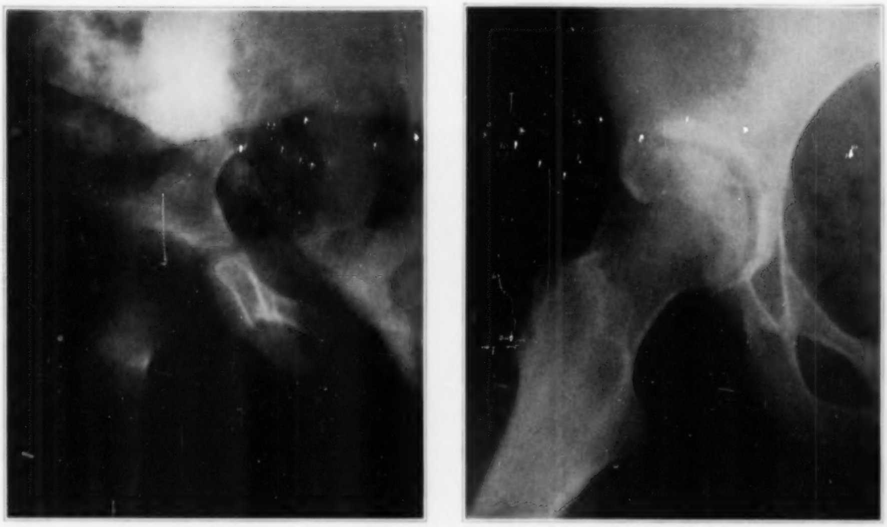

FIG. 10-A FIG. 10-B

Fig. 10-A: P. Z., a girl, four and a half years old. Roentgenogram shows preoperative state of the hip at the end of the first stage of the procedure. Second stage was performed December 5, 1932.

Fig. 10-B: Roentgenogram made nineteen years later shows that the depth of the socket has been retained and that there is good joint space. Excellent function is present today.

readily than the Smith-Petersen approach. With reasonable care, the branches of this nerve can be preserved by either approach, for the nerve enters the abductor muscles from the posterior border, well out of the path of any needed exposure.

It must be remembered that children three years of age or over have usually been

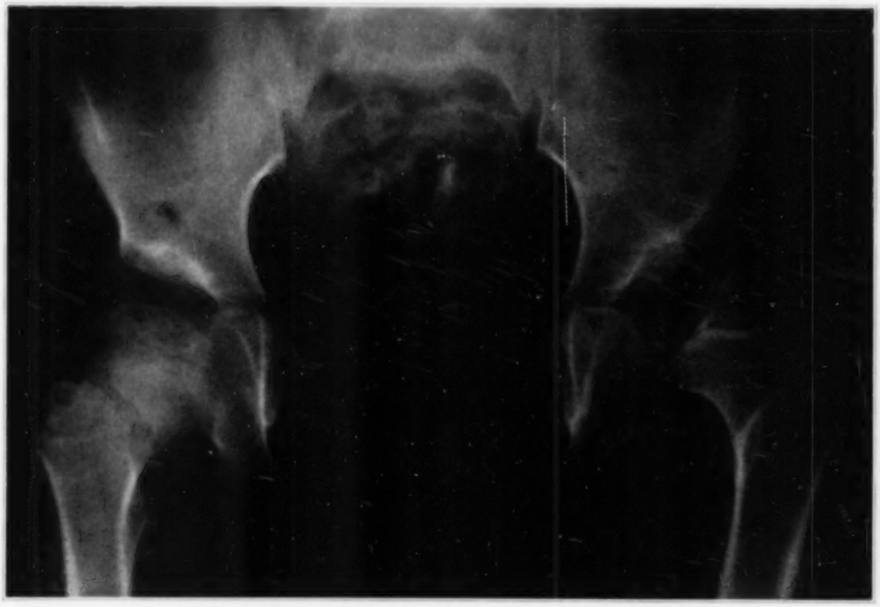

FIG. 11-A

D. K., a girl, four and a half years old. Roentgenogram made September 26, 1933, before the operation. The triangular-shaped head can be clearly seen.

walking for at least a year. The abductor muscles, therefore, have often become weakened by the malposition of the femoral head during this period of activity. There must have occurred some weakness of the muscle in these posterior dislocations; this may be a delaying factor in the return of strong abductor power in a few patients. It has been suggested that a transplantation of the tip of the trochanter and abductor muscles slightly downward on the lateral surface of the thigh and under the vastus lateralis would give added leverage. We have not felt this to be necessary, but there seems to be no reason why it may not be a logical suggestion to combat this infrequent complication.

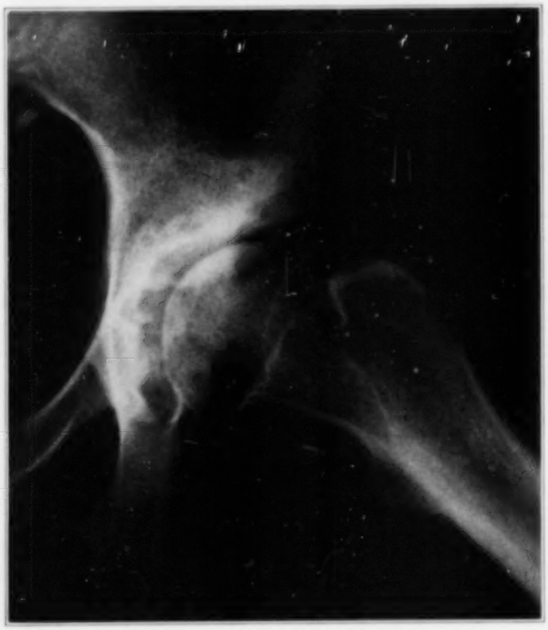

FIG. 11-B

Nineteen years later, a hip with good function and a semispherical femoral head have resulted.

Avascular Necrosis

Avascular necrosis has developed in some of the patients, but the interesting and the important fact is that it has not been a frequent complication within the age limit recommended for the operation—this in spite of the excision and removal of the ligamentum teres. Why this complication has not

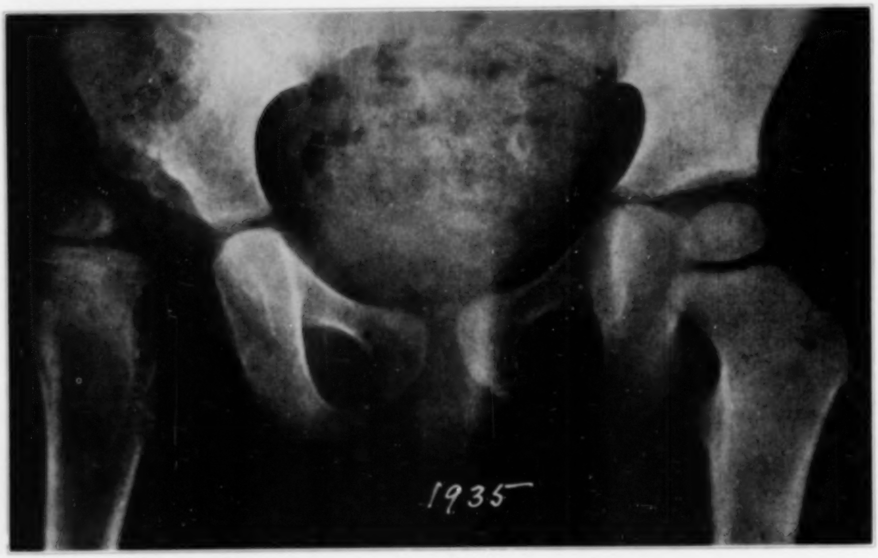
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FIG. 12-A

B. A., a girl, three years and ten months old. Roentgenogram made before the operation.

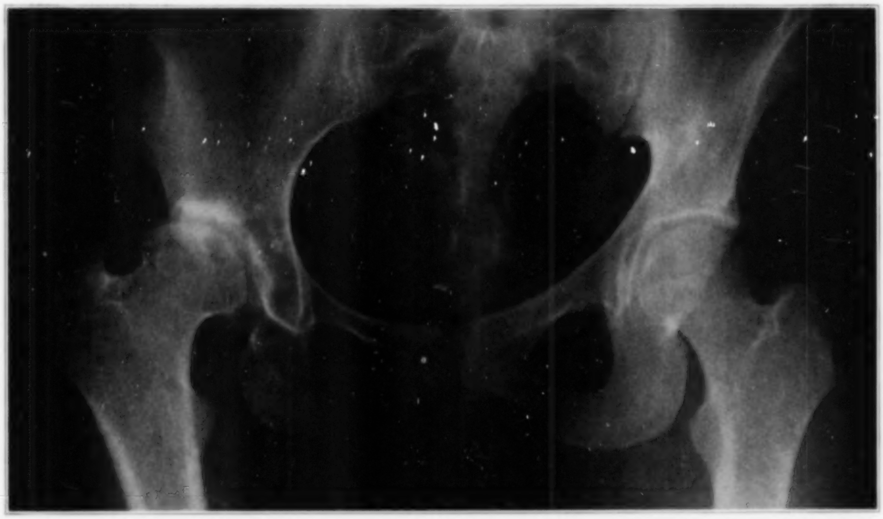

FIG. 12-B

Roentgenogram made sixteen years after the operation. During this time, the child had walked without a limp and had engaged in athletics, but a few months before this roentgenogram was made she had developed a slight limp and had tired easily after long activity.

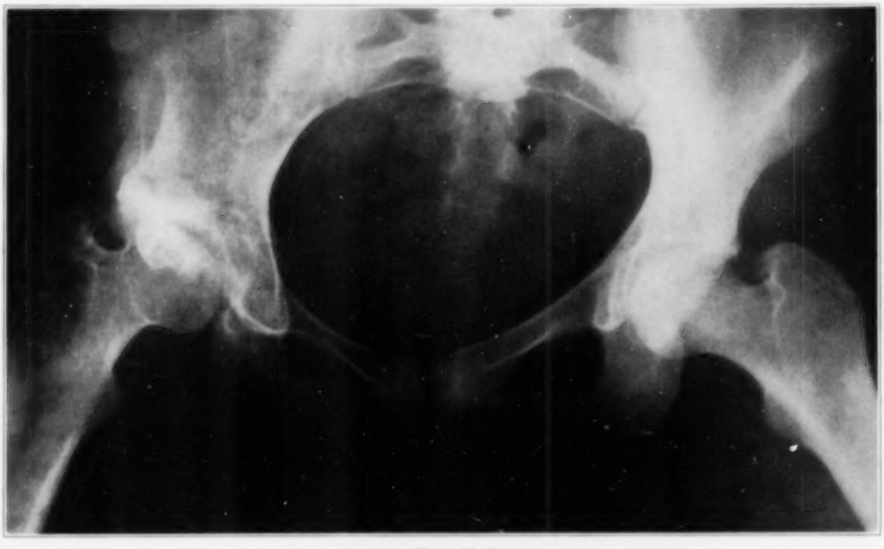

FIG. 12-C

Roentgenogram illustrates that this problem was overcome by the formation of an adequate buttress.

occurred more frequently we do not know, but we believe that it is due to the fact that the capital circulation is received through the arteries in the capsule about the head which is left intact at the operation. *Whenever there is roentgenographic evidence of avascular necrosis, the hip must be protected from weight-bearing*, as it is in Perthes' disease. Preferably protection should be accomplished by recumbency and traction in bed until there is evidence of revascularization of the capital epiphysis.

A study of the joint space in late follow-up roentgenograms will indicate very strik-

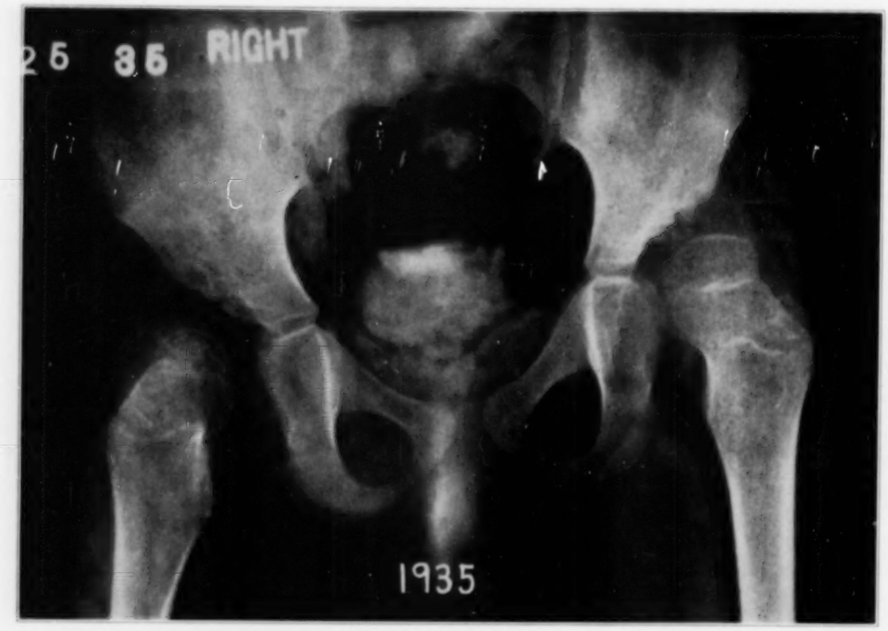

FIG. 13-A

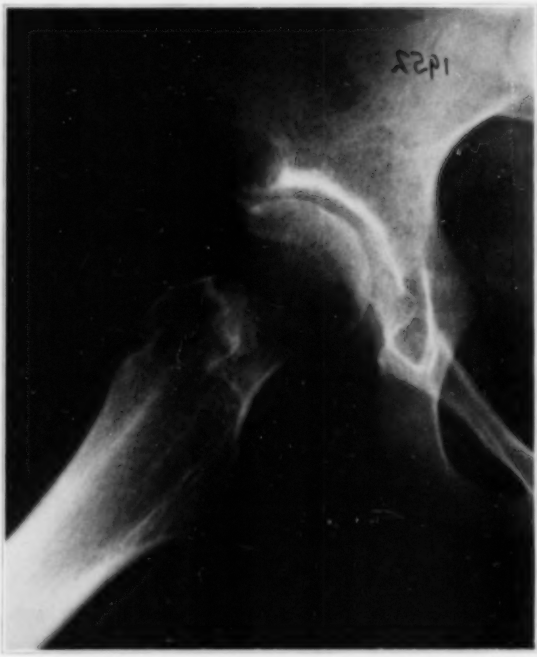

FIG. 13-B

Fig. 13-A: D. R., a girl, three years old. Roentgenogram made January 25, 1935, at the end of the first stage of the procedure.

Fig. 13-B: Roentgenogram made seventeen years after the operation shows good joint space and a stable socket. Excellent motion has been obtained.

ingly the range of motion present. If the joint space becomes narrowed, we feel that this is evidence of beginning functional disability. We watch for this narrowing closely, for it may be a forerunner of avascular necrosis or early arthritis.

Dislocation

Dislocation of the head has never been a complication, and with proper protection of the limb against adduction in the early months of postoperative care it should not occur. The firm attachment of the capsule over the head to the raw reconstructed bony walls of the acetabulum must occur early and should be firmly adherent within a month after the second stage of the operation has been performed.

Infection

While the possibility of infection in every surgical procedure can never be completely eliminated, it has not been listed as a serious complication in this operation. As far as we

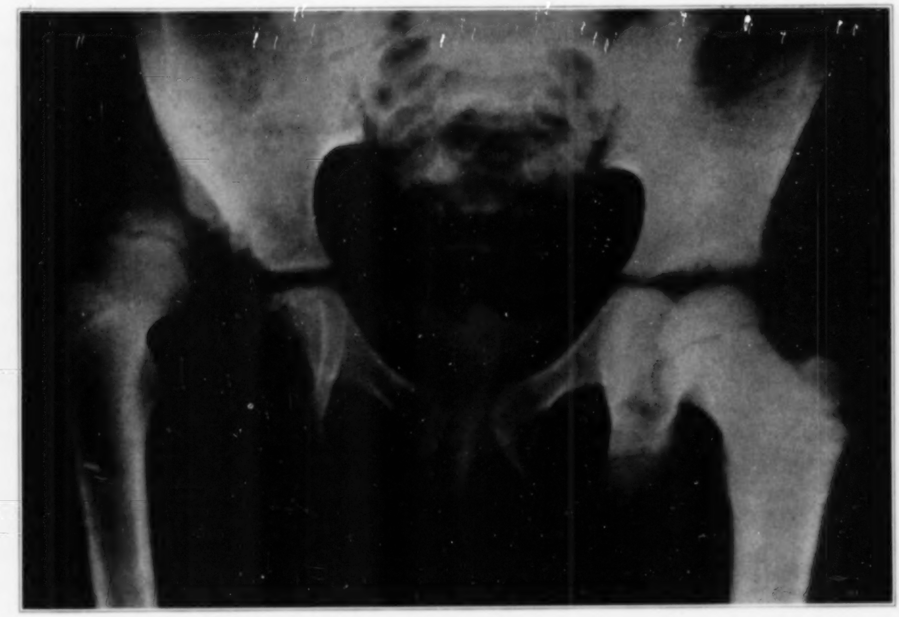

FIG. 14-A

A. Y., a girl, six years old. Roentgenogram made before the operation in 1932.

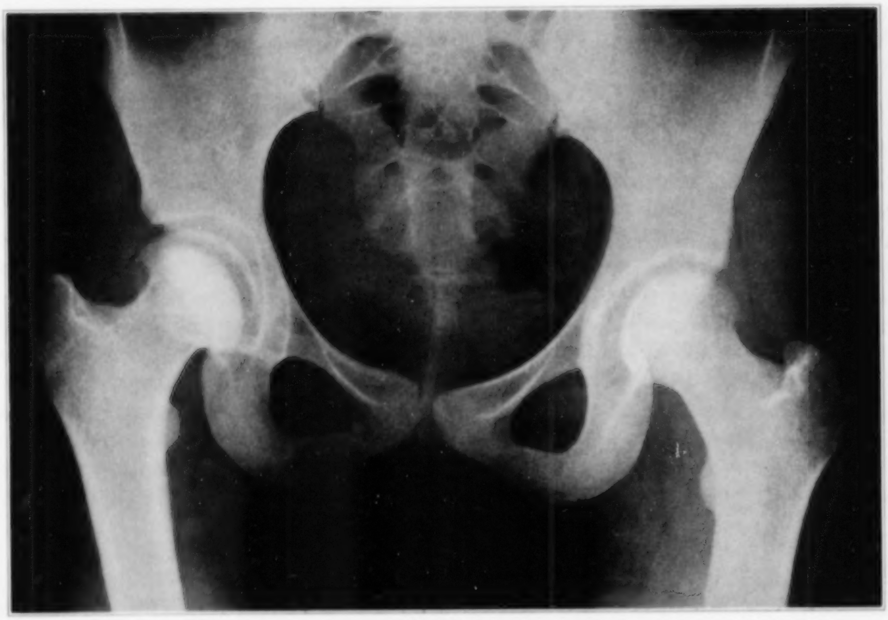

FIG. 14-B

Roentgenogram made twenty years later shows the semispherical head well seated in a deep acetabulum and a normal joint space. There is no limitation of motion.

know, it has not occurred beyond a superficial degree in any of the patients. It obviously could be a tragic factor in destroying future hip motion, but we have not had any patient in whom function has been impaired by infection.

Preoperative and Postoperative Roentgenograms

A great deal of information of prognostic importance can be elicited from both the preoperative and postoperative roentgenograms. A careful study of the appearance of the head and neck in the preoperative films may enable one to prophesy fairly accurately the degree of function which may be obtained following capsular arthroplasty (Figs. 6-A through 8-B).

In patients with the typical acorn-shaped head, an excellent functional result may be anticipated within the age limits previously outlined, while in those with markedly flat misshapen heads and underdeveloped necks, excellent motion must not be expected, even though stability can be assured. Anteversion is of varying degrees, and many methods have been devised to determine the degree preoperatively. We have not stressed this feature, for we feel that a secure seating of the capsule-covered head deep into the acetabulum is of primary importance and that this should be done at the time of open operation. In those who require correction of the anteversion, we have held the limb in internal rotation and slight abduction for two weeks and have then done a supracondylar osteotomy. After derotating the distal fragment so that the patella points upward, a long plaster spica is applied.

Two weeks later the fracture is sufficiently healed to allow the removal of the plaster spica and the application of a snugly fitting plaster casing from the groin to the ankle. At this time, balanced suspension, together with active and passive movement at the hip, is instituted.

Whenever an osteotomy is necessary, the supracondylar type is preferred to the subtrochanteric. It safely permits active movement of the hip two weeks later, while the healing supracondylar fracture is protected by the plaster casing (Figs. 9-A to 9-E).

The reconstruction of the acetabulum must be done carefully, and the new acetabulum should closely resemble the normal configuration, both as regards the *depth of the socket* and *the proper angle of the superior roof*. These are important features in the technique of the operation and, when carefully done, will ensure future stability. Too shallow an acetabulum or one with too sloping walls will always produce an insecure hip joint (Figs. 10-A and 10-B).

In a study of the postoperative roentgenograms, it has been found that there is no wandering of the acetabulum, if it is reconstructed as has been described. There will often develop with time a sclerotic rim about the superior margin which indicates increased bone density and resistance to the stresses and strains of normal activity. The more closely the remodeled acetabulum resembles the normal configuration at the time of its reconstruction, the more satisfactory will be the ultimate function (Figs. 11-A and 11-B).

The contour of the head is *never surgically altered*, but it will at times become remodeled by use and will appear, years later, spherical, although once it was triangular in shape. This must, in part, be dependent upon the configuration of the socket. When the late end results were studied, the modeling effect on the head was demonstrated a number of times. We have seen misshapen epiphyseal heads become spherical and normal-appearing after being placed in a smooth and adequate acetabulum (Figs. 12-A to 14-B).

SUMMARY

In performing this two-stage procedure for treating congenital dislocation of the hip in children, adequate preoperative soft-tissue stretching is followed by an open operation. At this time the capsule-covered head is transplanted downward and is centrally placed in an adequately formed and reconstructed acetabulum.

The indications, contra-indications, and complications have been reviewed in this twenty-year study and roentgenograms have been presented to demonstrate that stability can be achieved and mobility can be preserved in the congenitally dislocated hip.

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THE RAPID DEVELOPMENT OF A "SUBPERIOSTEAL BONE CYST" IN MULTIPLE NEUROFIBROMATOSIS

A CASE REPORT

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Among the protean manifestations of multiple neurofibromatosis is the occurrence of the bone lesion which was first described by Brooks and Lehman in 1924 and which was designated "subperiosteal bone cyst". This entity has been mentioned and described in numerous articles and reviews which have appeared since the original contribution by Brooks and Lehman, and it is considered by many authors to be a common occurrence in the osseous involvement of neurofibromatosis. However, in reviewing the literature, the author was able to find only four cases of the so-called "subperiosteal bone cyst" in which the cyst lay on the cortex of the involved bone and was covered by a lamella of new bone. Two cases were described in the original report of Brooks and Lehman. The third such lesion was reported by Holt and Wright in a roentgenographic study of thirty-seven patients who demonstrated some form of skeletal defect which could be correlated with the disease. The subperiosteal tumor in this case was present on the fibula, and roentgenograms demonstrated slow but progressive subperiosteal new-bone formation over a ten-year period. The fourth case was included in the series reported by McCarroll in 1950. The other bones involved in the reported cases included the radius, the clavicle, and the tibia. Operation was performed on the tibial lesion. This lesion was reported by Brooks and Lehman to contain "typical neurofibroma associated with new formed bone trabeculae". No previous case has been found by the author in which this tumor developed rapidly while the patient was under frequent observation.

The occurrence of such a lesion, together with the surgical excision of the tumor and the pathological examination, forms the basis for this report.

CASE REPORT

J. C., a white male, born June 30, 1937, was first seen at the New York Orthopaedic Dispensary and Hospital on January 16, 1940, at the age of two and a half years. At that time he was examined because of the complaint of occasional left limp, and a swelling on the medial aspect of the left ankle. He was observed at intervals in the Out-Patient Department until July 31, 1941, when he was admitted to the Hospital for biopsy of the swelling at the ankle, which had remained static during the period of observation. No family

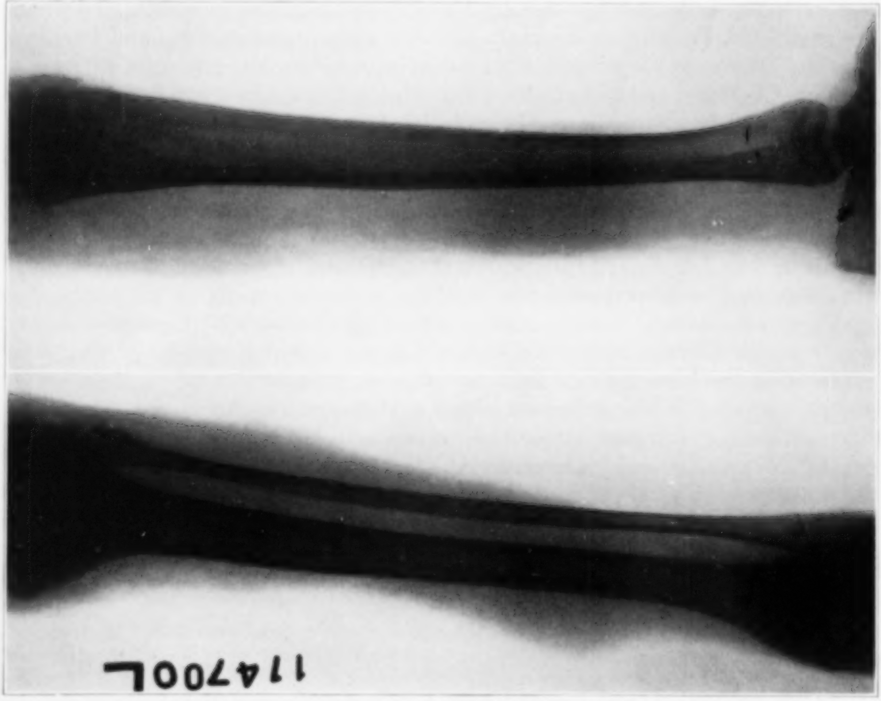

FIG. 1

July 11, 1950. Roentgenographic appearance of the lesion at the time of the first examination.

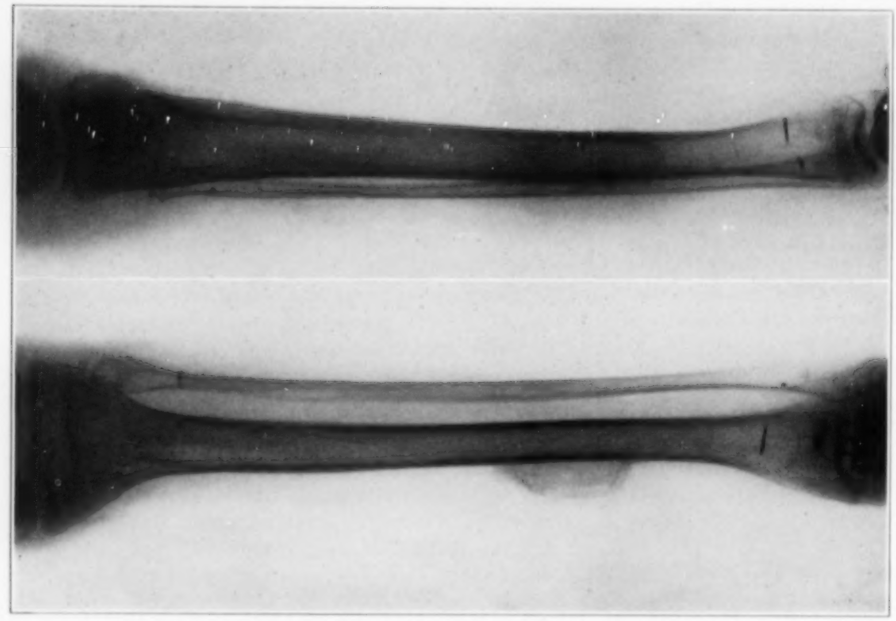

FIG. 2

August 9, 1950. Anteroposterior view shows rapid formation of new-bone lamellae, producing the appearance of the "subperiosteal bone cyst".

history of abnormality, cutaneous pigmentation, or deformity could be obtained. Examination was negative except for a soft-tissue mass about two by two centimeters below the left medial malleolus and a discrepancy of leg length in which the left tibia measured 1.5 centimeters longer than the right.

On exploration the mass was found to arise from the posterior tibial nerve. It was partially excised and the pathological diagnosis was neurofibroma arising from the posterior tibial nerve.

In subsequent years the patient had five additional periods of hospitalization, which are summarized as follows:

Second admission, August 1, 1946: The skin showed multiple *café au lait* pigmented areas. A right lumbothoracic scoliosis was present. A soft-tissue mass was palpable over the lateral aspect of the left calf. The left foot showed an early valgus deformity and was 1.5 centimeters longer than the right. The left lower extremity was five centimeters longer than the right, with equal overgrowth of the femur and of the tibia and fibula. The proximal tibial and fibular epiphyses were stapled at this time.

Third admission, October 27, 1947: The left lower extremity showed 5.7 centimeters overgrowth by scanograms. The valgus deformity of the foot had progressed. An epiphyseal arrest of the distal tibial and fibular epiphyses was done.

Fourth admission, February 8, 1949: The left foot had progressed into marked equinovalgus with severe plantar flexion of the talus. There was an early genu varum, apparently due to unequal growth at the proximal tibial epiphysis. Triple arthrodesis was done on the left foot at this time; later, during the same hospital admission, the medial staples were removed from the proximal tibial epiphysis, and a calcaneal-tendon lengthening was done.

Scanograms made in November, 1949, showed an overgrowth of the left femur of 2.7 centimeters and of the tibia of 2.1 centimeters.

Fifth admission, April 3, 1950: The remaining staples were removed, and an epiphyseal arrest of the proximal tibial and fibular epiphyses was done. The patient, wearing an elastic bandage, was discharged May 19, 1950, after an uncomplicated convalescence.

On July 11, 1950, the patient was seen in the Out-Patient Department with the history that, three days previously, he had noticed a large swelling on the lower part of the left leg. Examination showed a firm, slightly tender mass over the lower third of the left tibia on its anteromedial surface. The skin over the mass was normal in color and temperature. No bruit was present. Roentgenograms showed a rounded soft-tissue density overlying the subcutaneous surface of the bone (Fig. 1). An attempt was made to aspirate the mass for a suspected hematoma. No fluid was obtained.

Sixth admission, August 4, 1950: A large hard mass was present on the medial aspect of the lower third of the tibia. Since it was believed that the mass had grown rapidly in the previous few weeks, a malignant neoplasm was suspected. Roentgenograms made on August 9 (Fig. 2) showed that since the previous films were made on July 11, a large dense shadow had appeared along the surface of the tibia at and just below the juncture of the middle and lower thirds of the shaft. The findings were interpreted to be suggestive of a calcified hematoma, but a malignant process was not excluded. In view of the rapid appearance and ossification of the lesion, a clinical preoperative diagnosis of subperiosteal hematoma with calcification was made, although no specific history of injury could be obtained.

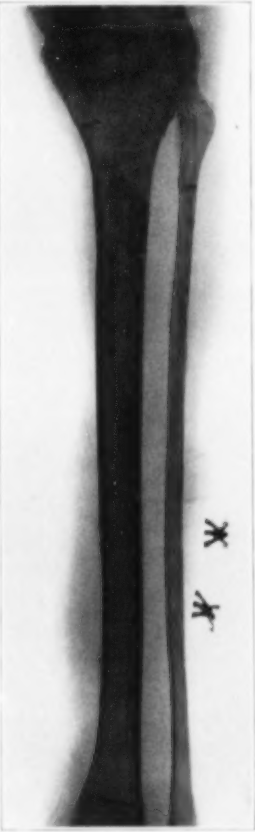
FIG. 3

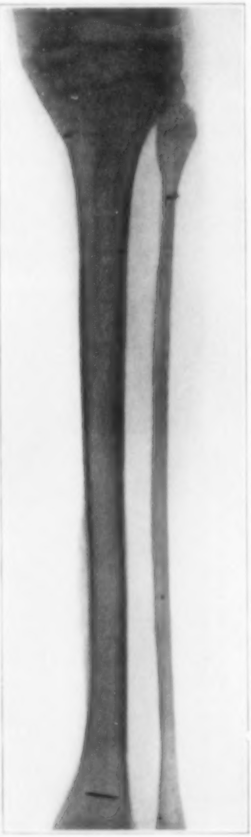
FIG. 4

Fig. 3: Postoperative view after excision of the mass.

Fig. 4: Three months postoperative, showing some new-bone formation at the operative site.

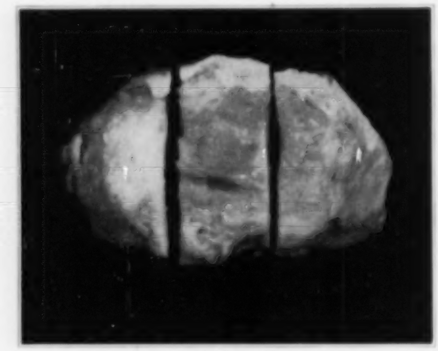

FIG. 5-A

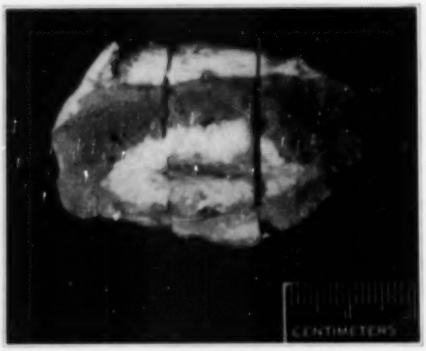

FIG. 5-B

Fig. 5-A: External view of the hemi-ovoid mass removed from the tibia (specimen, actual size).
Fig. 5-B: Longitudinal section showing central mass of white soft (neurofibromatous) tissue surrounded by bone which in turn is covered by a layer of white (periosteal and neurofibromatous) tissue.

On August 18, the area was explored; the mass was excised with its overlying periosteum. At operation a subperiosteal bony mass three by five centimeters was encountered which was attached to the surface of the tibia. In no way did it erode or penetrate the cortical surface of the tibia. The overlying periosteum was thickened. A branch of the saphenous nerve which traversed the periosteum was not connected with it. The bony shell consisted of a thin layer of soft cancellous new bone; the body of the mass consisted of a firm, rubbery, white fibrous tissue.

The patient's postoperative convalescence was uncomplicated. The postoperative roentgenograms showed that some small remnants of the bony shell remained at the operative site.

Roentgenographic examination three months after the operation (Fig. 4) revealed some bone production and an irregularity along the shaft of the tibia. Clinically, there was recurrence to a limited extent of the

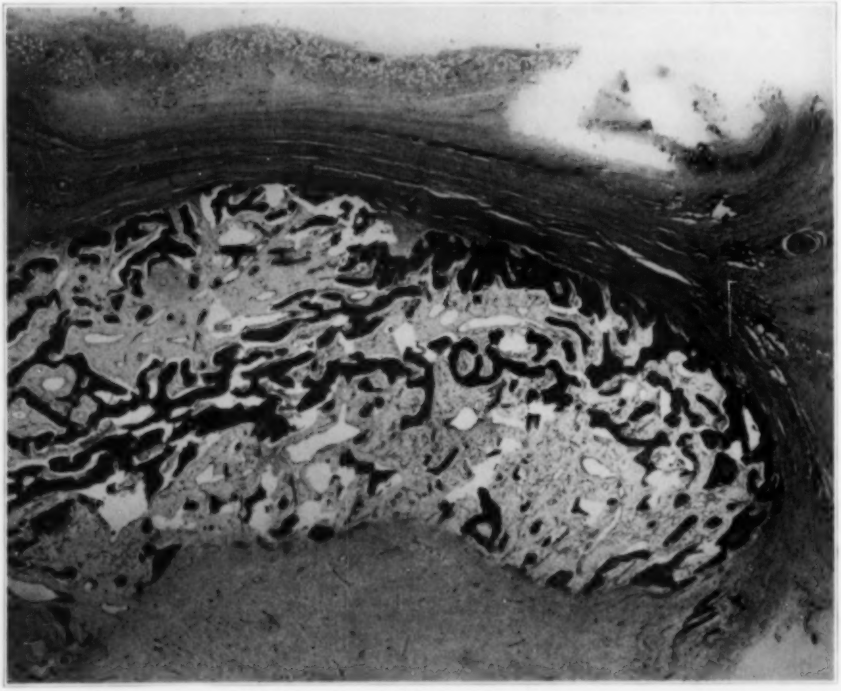

FIG. 6

Low-power view (× 10.3) in cross section. In the external periosteal tissue at the top and to the right is a small whorled pattern of a neurofibromatous nerve.

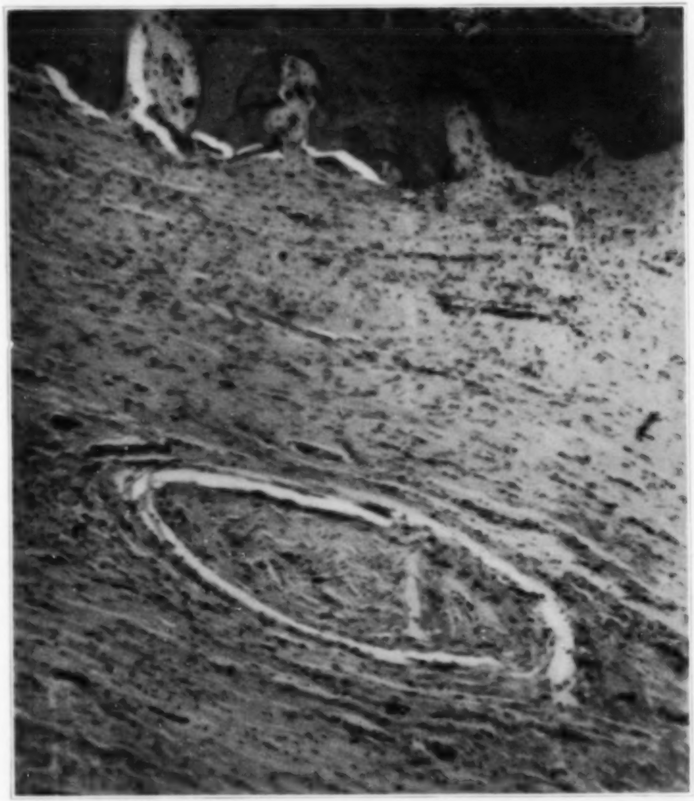

Fig. 7

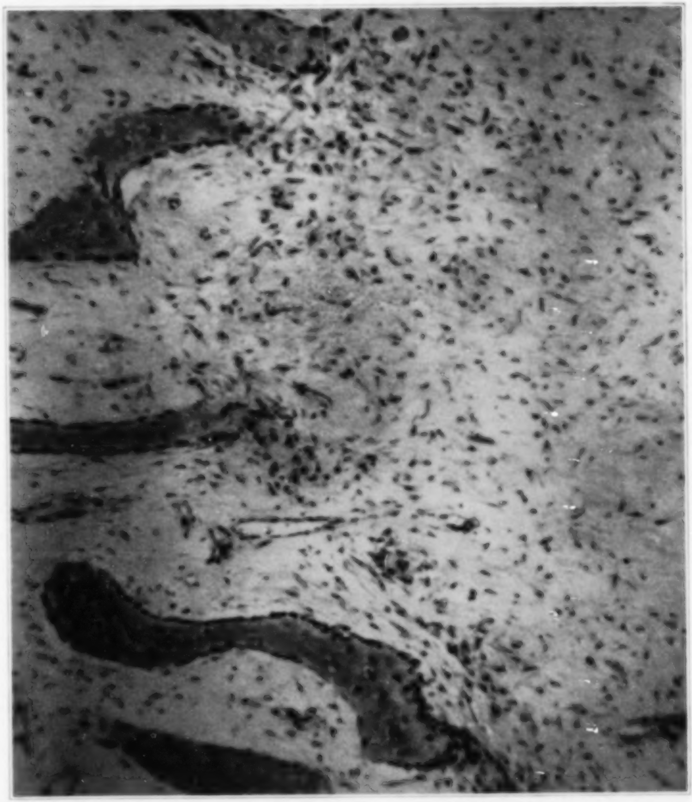

Fig. 8

Fig. 7: Moderately high-power magnification (× 100) of the whorled neurofibromatous tissue seen in Fig. 6.

Fig. 8: Diffuse growth of neurofibromatous tissue associated with trabeculae of osteoid tissue. This section (× 100) was taken from the margin of the large central mass of white tissue which was partially surrounded by bone.

bony mass with some questionable soft tissue present. This has, however, remained stationary from about the second month after the operation.

Pathological Examination

The specimen consisted of a hemi-ovoid mass of bone measuring five by three by 1.3 centimeters and five pieces of bone and tissue measuring fifteen to twenty by eight by one to five millimeters. The convex surface of the large mass was covered by white tissue of moderately firm fibrous consistency (Fig. 5-A). The opposite side was a freshly cut flat surface of moderately dense cancellous bone without any perceptible cortex. At the periphery there was a layer of white tissue, three to five millimeters in thickness. Occupying the center of this flat surface was an ovoid mass of white, somewhat striated, semitranslucent tissue of moderately firm fibrous consistency which measured 3.5 by 1.5 centimeters (Fig. 5-B). In cross section, the white fibrous tissue exhibited a hemispherical shape. One edge was continuous with the grayish-white tissue which covered the convex surface of the bone. In a few areas of contact with bone, this tissue had a light orange-brown coloring. The peripheral layer could be rather easily pulled away, and a uniformly slightly roughened surface of bone was left. Although the central and peripheral areas of white tissue were slightly different in appearance, they were connected in one region and seemed to be related to the same pathological process. Three of the smaller pieces of tissue showed a small amount of white tissue attached to the bone, similar to that seen in the larger specimen.

Microscopic Examination

All sections showed moderate-sized interlacing trabeculae of rather immature bone which were bordered by numerous osteoblasts and a few osteoclasts. The intervening spaces showed no trace of blood formation or of adipose tissue and were occupied by a delicate open network of fine, interwoven, poorly staining, long fibers. The fibers originated from elongate or stellate cells with scanty cytoplasm and rather small oval or elongate vesicular nuclei which exhibited a single nucleolus and a rather small amount of finely granular chromatin. These cells bore some resemblance to fibroblasts; but most of them were smaller and their fibers were more delicate. In the network of very thin, pale-staining fibers were many small blood capillaries and a few large blood-filled spaces which were bordered by a single layer of endothelium.

The large white mass of tissue, noted grossly in the central area of the bone, was seen in the sections to be continuous with and composed of the same type of loosely interwoven delicate cells as were found between the bone trabeculae (Fig. 6). There was no suggestion of whorl formation. At the line of the juncture of this large area of tissue with the concave margin of bone, the bone was quite immature. Nearby there were small islands of osteoid tissue, associated with osteoblasts which had been formed by metaplasia of elongate and stellate cells. In the great mass of the interwoven delicate cells, there were a few scattered small round cells and a moderately large number of blood capillaries. Further away from the bone and near the periphery of the section, the fibers were more numerous and more closely together as they are in fibrous connective tissue.

The convex margin of bone, as seen grossly, exhibited in the microscopic sections some erosion of bone trabeculae and, in places, some newly formed bone. The overlying connective tissue contained an abundance of collagen fibers and resembled periosteum. However, it contained a considerable number of small blood vessels and blood capillaries and a few abnormal, moderate-sized nerve funiculi which showed, in one instance, concentrically arranged coarse fibers in a much thickened perineurium and, in another instance, concentrically and loosely arranged fine fibers in a typical pattern of neurofibromatous tissue. The tissue of the large whorl formation made peripheral transition to more irregularly arranged, fine-fibered cells of the type already described in association with bone (Figs. 7 and 8).

Diagnosis

The diagnosis of neurofibromatosis of the periosteum associated with the formation of a large bowl-shaped mass of immature bone (tibia, left) was made.

DISCUSSION

Brooks and Lehman in their original report stated that "with the development of a neurofibroma of a nerve in the periosteum, there is set up a certain amount of reaction, and bone destruction and regeneration follow. If, in the process of the development of the tumor, the osteogenetic element of the periosteum comes to cover over the tumor, then a thin shell of bone is formed over it and thus the x-ray appearance of a subperiosteal bone cyst is produced." In their series of seven patients with osseous manifestations of the disease, they found that the irregularity in outline of bone varied from slight irregularity of the periosteal and cortical structure of the bone to large tumors projecting from the surface of the bone or embedded as cyst-like cavities in the structure of the bone. Weber reported in 1930 a case of diffuse periosteal neurofibromatosis involving the periosteum of the entire upper three fourths of the tibia, with periosteal thickening to a half inch. Specimens showed the typical microscopic picture associated with neurofibromatosis. He also mentioned a specimen of an amputated leg in the Museum of the Royal College of Surgeons with diffuse periosteal thickening of the shafts of the tibia and fibula. Weber and other students of the disease have concluded that overgrowth of the bones and other osseous anomalies are directly related to neurofibromatous involvement of the periosteum or of the bone itself. It is of interest that in this case overgrowth of the lower extremity was present ten years before the development of any evidence of direct neurofibromatous relation to the bone. Furthermore, the abnormal length of the extremity was divided proportionately between the femur and the bones of the leg, although there was no apparent direct relationship between the neurofibromatous growth and the femur.

CONCLUSIONS

The "subperiosteal bone cyst", first described by Brooks and Lehman, is an unusual manifestation of multiple neurofibromatosis. It consists of a neurofibroma which probably arises from a periosteal nerve, elevates the periosteum from the cortex, and stimulates the rapid formation of a lamella of new bone which partially encapsulates the tumor. Neurofibromatous tissue can also be identified in the periosteal layer on the convex side of the newly formed bone, and direct continuation of neurofibromatous tissue can be demonstrated between the tissue on the convex side and on the concave side of the new bone lamellae. There is no invasion of the cortex with this lesion; and, with its rapid development, it may pose a problem in diagnosis which must be resolved by exploration and removal. Disturbances of bone growth in this case do not seem to be dependent on direct neurofibromatous involvement of bone, and such aberrations of bone growth may be interpreted as evidence of a congenital mesenchymal defect.

NOTE: The author is indebted to Dr. C. Zent Garber for the pathological report and the illustrations included in this article.

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OSTEOPETROSIS IN AN ADULT

A Case Report

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Albers-Schönberg's [1] disease was first described in 1904, and received the name now most commonly used, osteopetrosis, from Karshner in 1926. The etiology is unknown. The symptoms, laboratory findings, pathogenesis, and roentgenographic findings are quite familiar to orthopaedic surgeons and are well discussed in recent texts on bone pathology [4, 6] and on roentgenology [3].

The following case is presented because of the unusual roentgenographic findings.

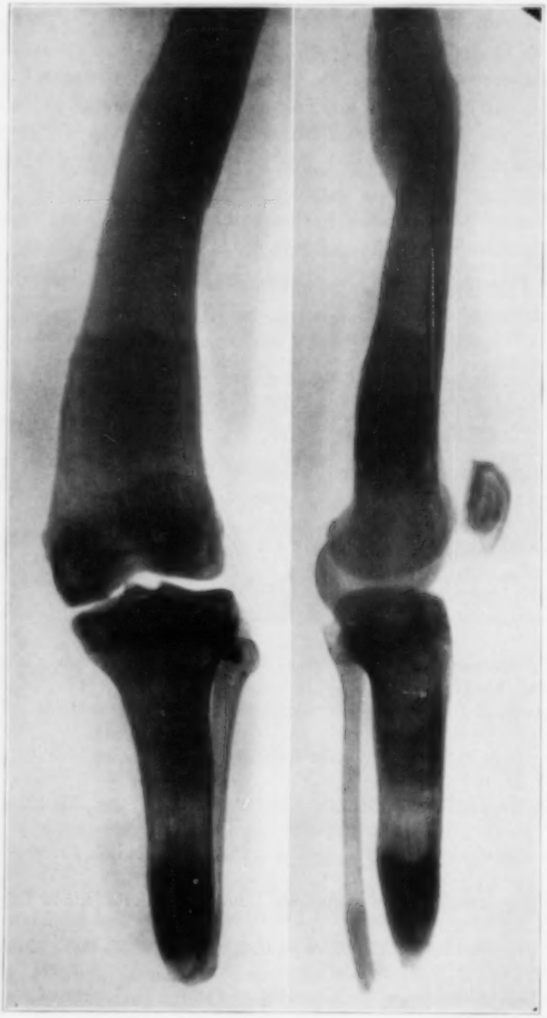

Fig. 1

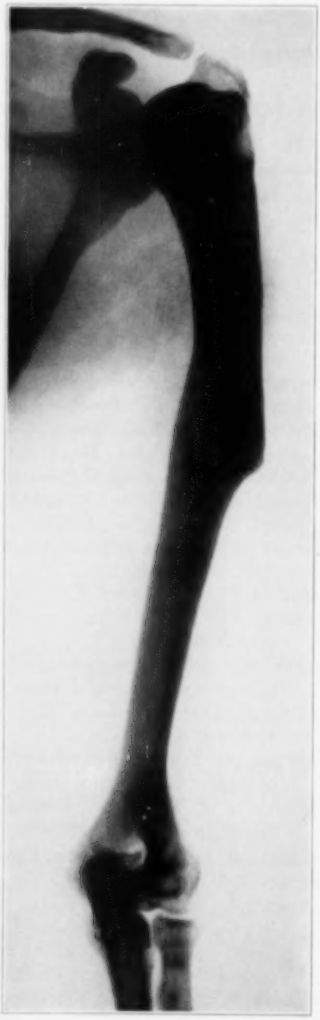

Fig. 2

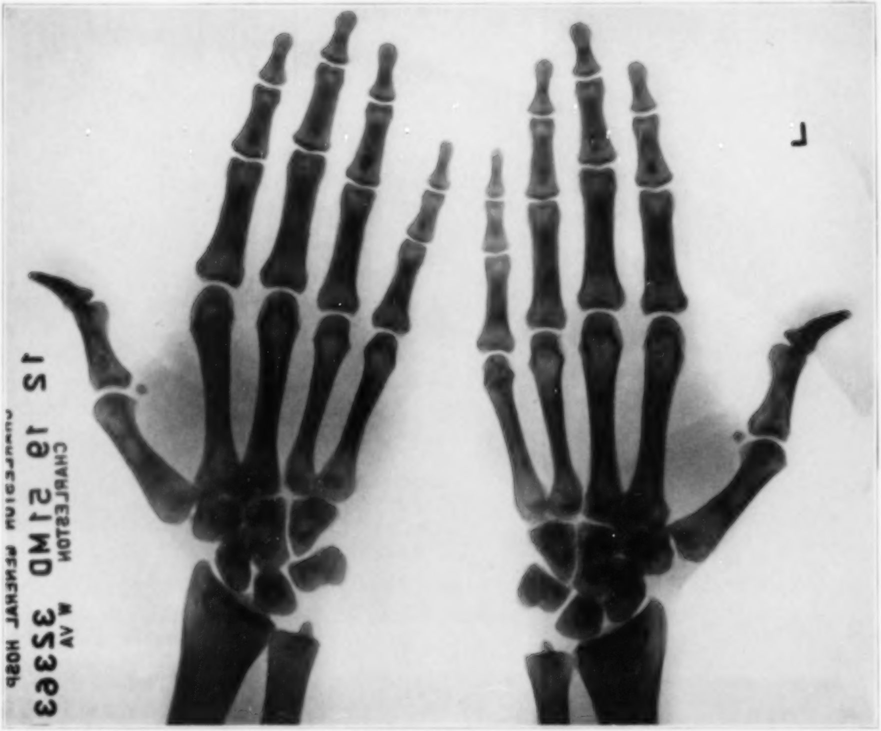
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Fig. 3

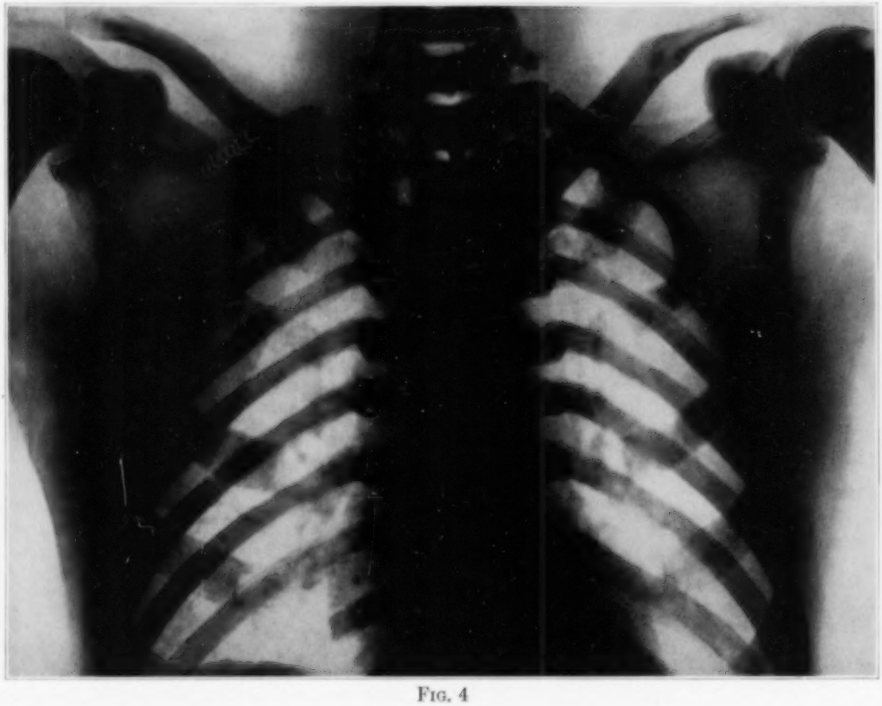

Fig. 4

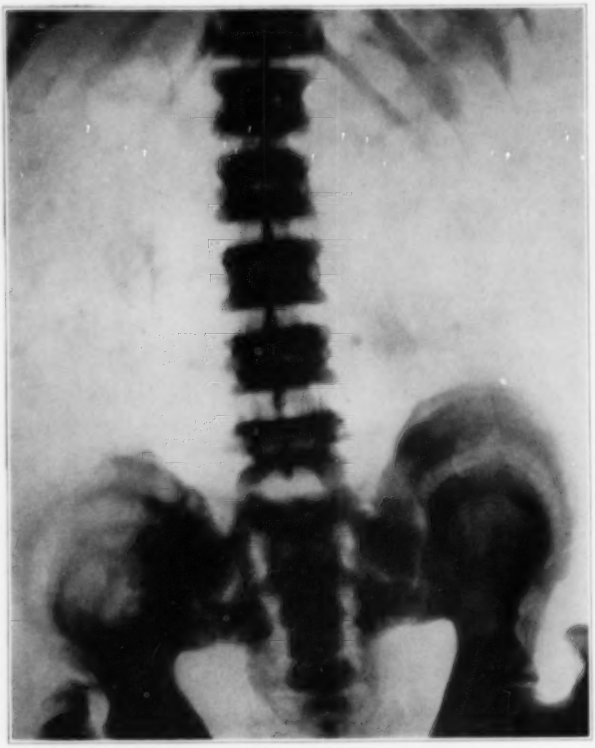

FIG. 5-A

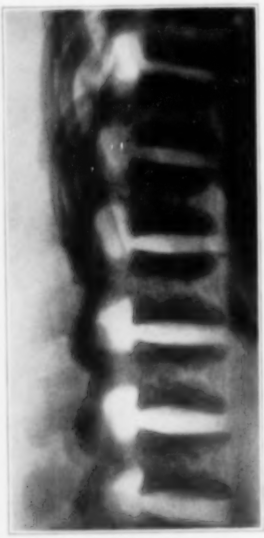

FIG. 5-B

W. M., aged 29, was admitted to the hospital with the chief complaint of inability to bear weight on the right hip because of pain. He was in good health and had been working steadily in a boiler factory until 1949. One day he reached up to release a lever with his right hand, while bearing his weight upon his left lower extremity (and the prosthesis); the right limb was not off the ground. Upon releasing the lever, he came down with his full weight upon the right lower extremity. He felt a sharp pain and stood on the left limb until a chair was obtained, placing no weight upon the right. Because of the history of a minimal trauma, he was treated for three and one-half months with injections for rheumatism. He gradually became ambulatory with the aid of a cane.

FIG. 6

Previously, in 1931, a below-the-knee amputation had resulted when he was run over by a train. He had broken his clavicle in 1937 when he struck his shoulder against a tree while swinging, and he had fractured the left humerus in 1941 when he fell from his bicycle. In 1945, he stumbled and broke his left femur.

No other person in his family had been affected. No history of consanguinity of his parents was obtained.

A review of systems was negative.

The general examination was negative. The deformities of the previous fractures and the left below-the-knee amputation were noted. Examination of the right thigh revealed pain on flexion and rotation. A grinding noise was noted on manipulation as well as a definite telescoping of the hip.

Laboratory examination revealed the urine analysis and complete blood counts to be within normal limits. Values obtained from blood studies were: prothrombin time, 100 per cent., non-protein

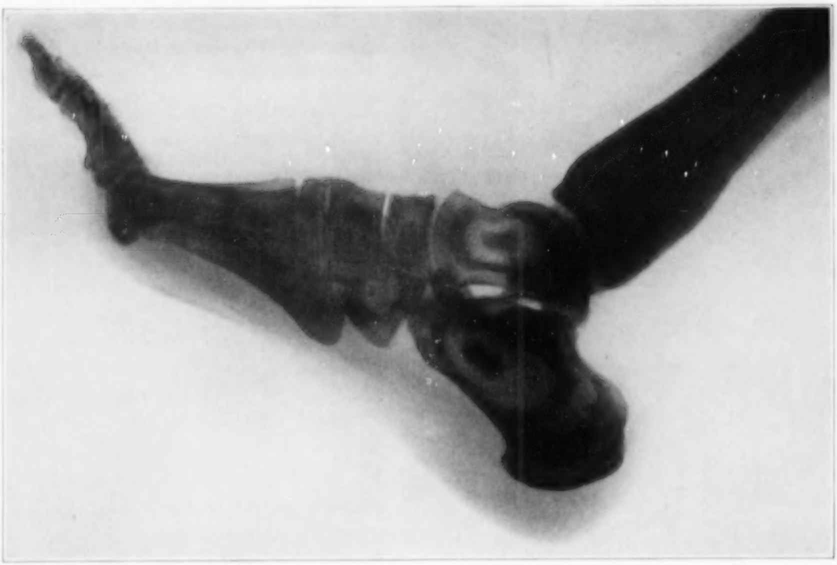

FIG. 7

nitrogen, 40.25 milligrams per 100 milliliters of whole blood; total serum protein, 7.6 grams per 100 milliliters; serum albumin, 4.83 grams per 100 milliliters; serum globulin, 2.77 grams per 100 milliliters; serum calcium, 9.03 milligrams per 100 milliliters; inorganic phosphorus, 4.7 milligrams per 100 milliliters of blood serum; serum alkaline phosphatase, 5.6 Bodansky units. The Mazzini test for syphilis was negative.

The amount of urine excreted in twenty-four hours was 2,000 cubic centimeters. The urinary excretion of calcium during this period was 93 milligrams.

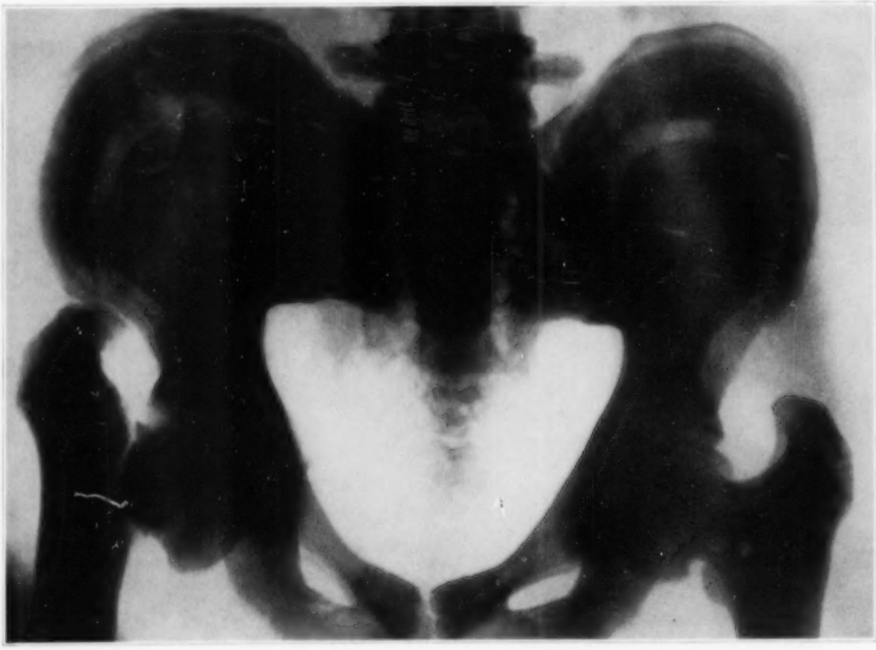

FIG. 8

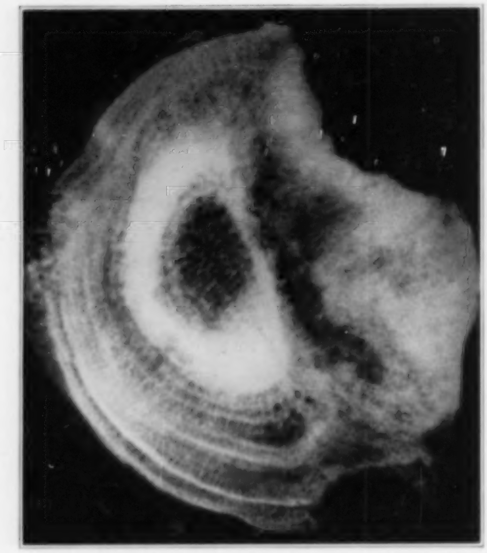

Fig. 9

The roentgenographic examination revealed characteristics of marble bones throughout all of the skeleton.

According to Brailsford, the most characteristic picture roentgenographically is simulated by no other disease. "The most rapidly growing extremities of the long bones show the most marked changes, namely, the lower thirds of the femora and radii, and upper thirds of the tibiae and humeri. These extremities are composed of dense bone in which no cancellous trabeculation can be detected, and as far along the shaft as this change has occurred the bone is expanded and club-like in appearance. If hard rays are used in taking the radiographs, multiple closely packed transverse lines parallel with the metaphyseal growth cartilage will be seen indicating that accretions of dense bone are laid down as such from the growing cartilage, the epiphysis as well sharing in the transformation."

A slight increase in translucency may be seen as a semblance of a medullary cavity in the area not affected by the clubbing. The non-ossified epiphyseal cartilage is normal in thickness (Figs. 1, 2, and 3).

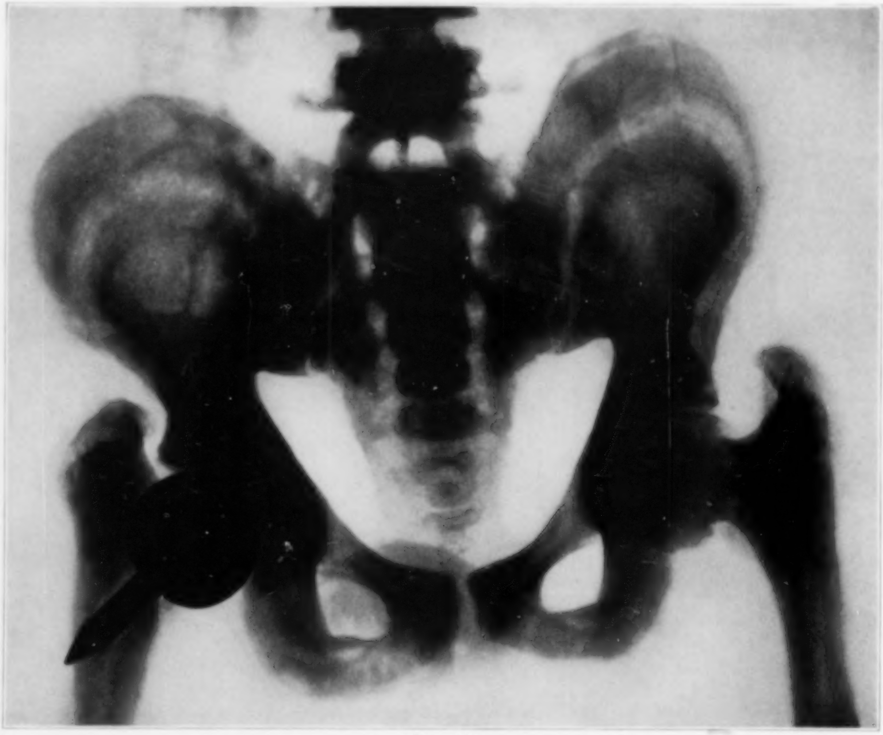

Fig. 10

The ribs are quite opaque; the costochondral juncture, however, is unaffected (Fig. 4). The iliac bones may show a pattern of alternating bands of density similar to that found in the ends of the long bones.

The vertebral bodies may show three zones, upper and lower dense zones with an intermediate zone of almost normal density, which indicate that the changes have occurred by accretion of new bone from growing cartilage (Figs. 5-A and 5-B).

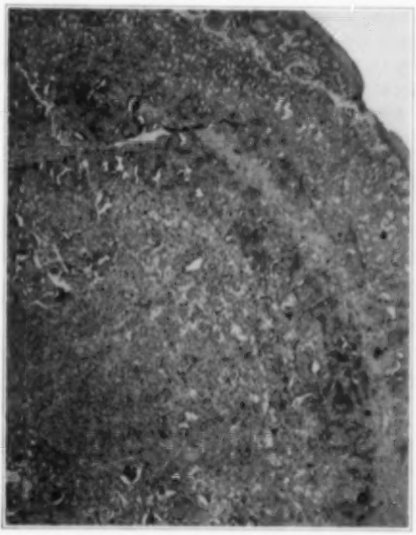

FIG. 11

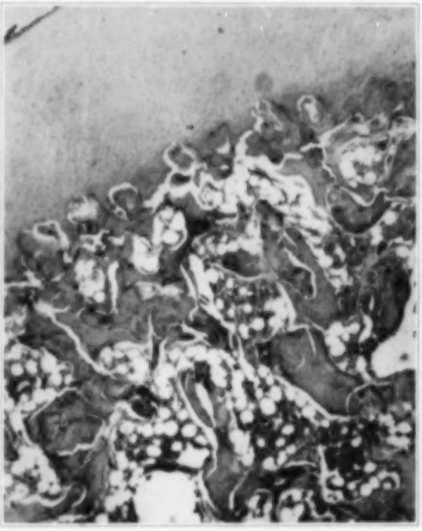

FIG. 12

Fig. 11: A low-power view (× 15) of a section through the head of the femur reveals a slight arthritic defect of the joint cartilage and dense layers of primitive bone and cartilage with very little hemopoietic marrow.

Fig. 12: In this medium-power view (× 57) are seen plump primitive bone trabeculae with cartilaginous inclusions adjacent to the joint cartilage of the head of the femur.

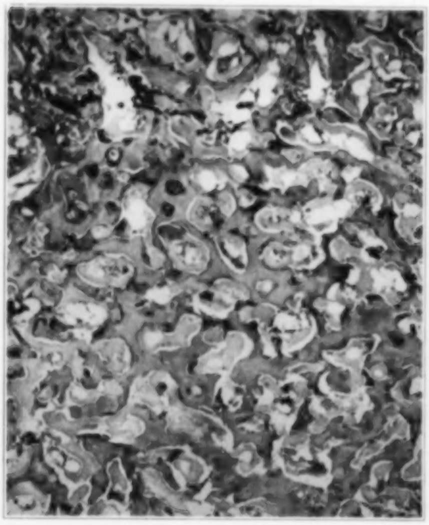

FIG. 13

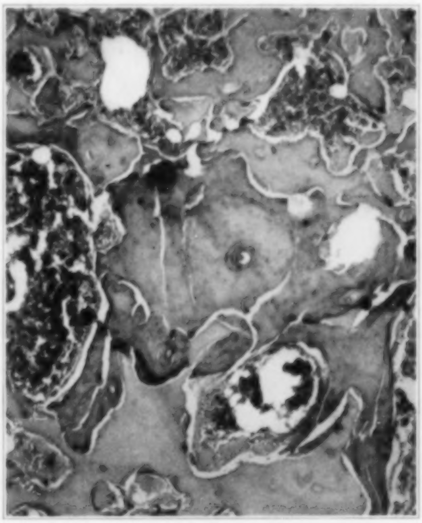

FIG. 14

Fig. 13: The central portion of the head of the femur from the area of greatest density shows an interlacing network of non-functional bone around rests of cartilaginous matrix. The marrow spaces are almost entirely absent (medium power, × 57).

Fig. 14: Seen within a less dense area, in this high-power view (× 142), is one of the few Haversian systems built onto a primitive bone trabecula.

The skull may be so dense as to show no bone detail. Bony prominences may be markedly thickened and the foramina diminished in size. The diminished caliber of the foramina is also due to the failure of remolding (Fig. 6).

The carpals, tarsals, patella, the proximal ends of the femur, humerus, and tibia, and the distal end of the femur show similar circumferential areas of varying densities (Figs. 1 and 3). A centrally located dense mass representing the calcified cartilaginous anlage of the bone may be seen in the carpals and tarsals. This is most prominently visualized in the roentgenograms of the calcaneus, talus, and cuboid (Fig. 7).

The metacarpals, metatarsals, and phalanges may show expanded clublike proximal and distal ends (Figs. 3 and 7). There also may be visualized in these bones an area of increased density as evidence of the calcified cartilage anlage. In Figure 3 they are most prominent in the proximal portion of the middle phalanx.

Fractures unite without excessive callus formation in the normal period of time. However, as in a fracture of the femoral neck in normal bone, non-union may result. In roentgenograms, the femoral head may show a homogenous density or may show some semblance of circumferential bands of varying densities (Fig. 8). A roentgenogram of a thinly cut section of the head shows these bands dramatically (Fig. 9).

Excision of the head of the femur was performed and an attempt was made to produce a tract for the insertion of an Eiker prosthesis. Even with vigorous pounding, no tract was made. The reamer for the Naden-Reith prosthesis was then employed, and a tract for the prosthesis was reamed with difficulty. Before the hole was extended through the outer cortex of the femur, an attempt was made to drive the prosthesis into place. The tip of the prosthesis was bent back upon itself. The tract was deepened through the outer cortex and the prosthesis was driven home. An extremely firm fixation of the prosthesis resulted (Fig. 10).

The gross specimen of the femoral head revealed areas of denuded cartilage with the articular cortex visible and with dense eburnated bone at the site of non-union. Thinly cut sections of the head further showed circumferential bands of alternating densities.

A roentgenogram of a slab of the head of the femur showed concentrical layers of increased density with very little functional structure; there was a marked increase in density at the site of the ununited fracture through the femoral neck (Fig. 9).

Histological studies of the specimen gave some interesting findings (Figs. 11 through 14).

NOTE: The authors wish to thank Dr. Walter Putschar for his cooperation and assistance in reporting the pathology.

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CHONDROMYXOSARCOMA OF THE CALCANEUS

Report of a Case of Total Replacement of Involved Bone with a Homogenous Refrigerated Calcaneus

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The use of refrigerated homogenous bone grafts has marked a definite advance in orthopaedic surgery. The authors have used bone removed in operations and bone from fresh cadavera when these have been available; they have used the technique of Velasco Zimbron[1], from Mexico.

The case here reported represents a total substitution of a calcaneus removed from the body of a woman who had died twelve days previously.

On July 28, 1948, a boy, fourteen years old, came to the Hospital complaining of a sprain of the left ankle of four months' duration, caused by coming down hard on his foot when he was getting off a horse. There had been no previous symptoms in the ankle.

In spite of the lesion, the patient's general state of health was good. The left foot was swollen, particularly on the lateral aspect of the calcaneus, below and behind the peroneal tendons. The local temperature was normal. There was no venous circulation and there was no gland infarct.

Laboratory findings were negative, as were the roentgenographic studies of the lungs.

Roentgenograms of the calcaneus showed a vacuolar osteolytic shadow with a clear outline and septa of bone trabeculae (Fig. 1).

Aspiration biopsy performed on August 3, 1948, proved the lesion to be chondromyxosarcoma. This diagnosis was later confirmed by surgical biopsy (Fig. 2).

An operation was performed on August 31, 1948, under pentothal anaesthesia. A pneumatic tourniquet was used. A lateral incision was made along the Achilles tendon to below the lateral malleolus and from there as far as the base of the fifth metatarsal. The whole of the calcaneus was removed (Fig. 3-A), the periosteum being left in place. The tourniquet was then released and hemorrhage was controlled. A calcaneus which had been removed from a cadaver twelve days before and kept in the deep freezer was substituted. In order to maintain blood supply, the bone was drilled in several directions and subtalar and calcaneocuboid arthrodeses were performed. The calcaneus was fixed to the talus by means of an ordinary bilaminar femoral nail (Fig. 3-B). The Achilles tendon was stitched to the calcaneus with chromic catgut. Closure by layers was followed by application of a plaster cast. The postoperative course was uneventful.

On September 30, 1948, the cast was opened. The wound was completely healed. Roentgenograms showed the bone to be necrotic (Fig. 4). New plaster was applied. The patient was discharged but weight-bearing was forbidden.

In April 1949 the plaster was removed. The appearance of the foot was quite satisfactory. The roentgenograms showed sound fusion between the calcaneus and the talus and revascularization was shown to have begun. The nail was removed under anaesthesia (Fig. 5), as well as a small fragment of the transplanted bone for study. Connective tissue with newly formed blood vessels had advanced between the necrotic bone trabeculae (Fig. 6). The leg was again put in plaster.

On September 13, 1949, the general condition of the patient was satisfactory, and

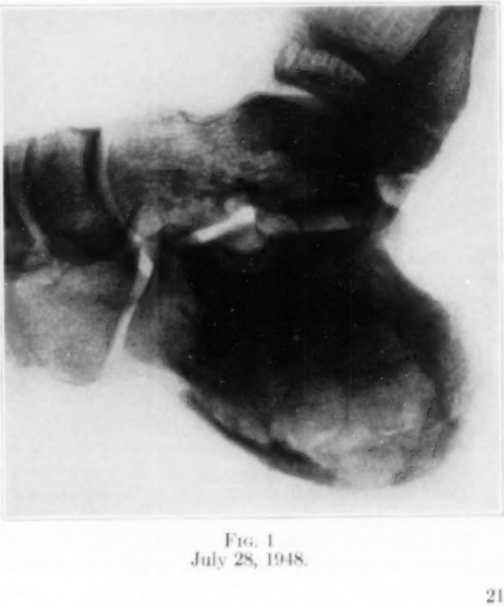

Fig. 1

July 28, 1948.

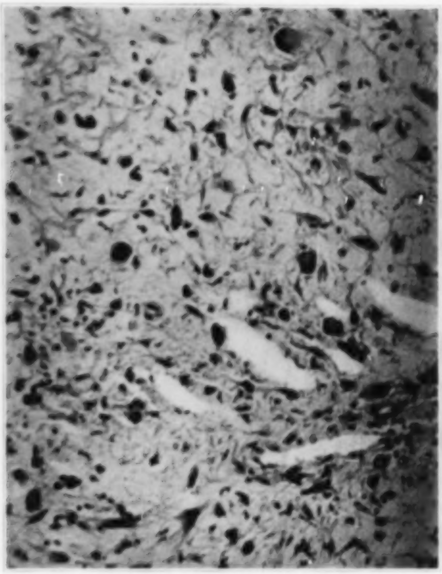

FIG. 2
Specimen from surgical biopsy.

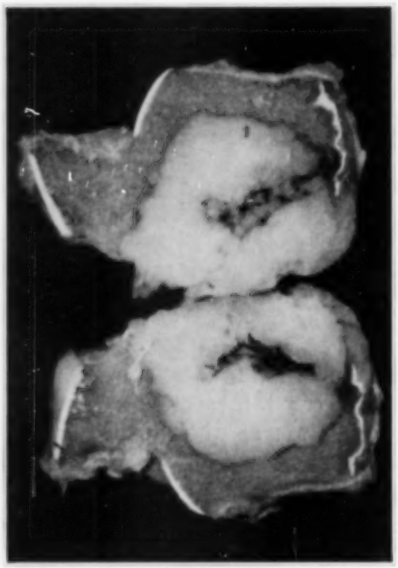

FIG. 3-A
Gross specimen excised August 31, 1948.

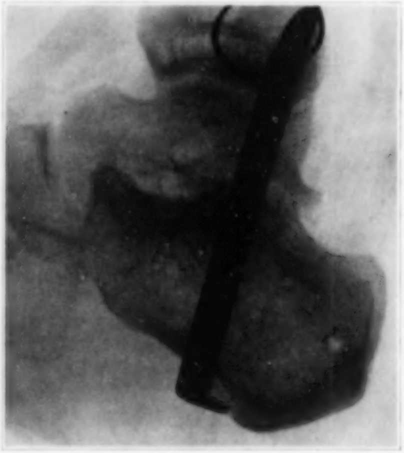

FIG. 3-B
August 31, 1948.

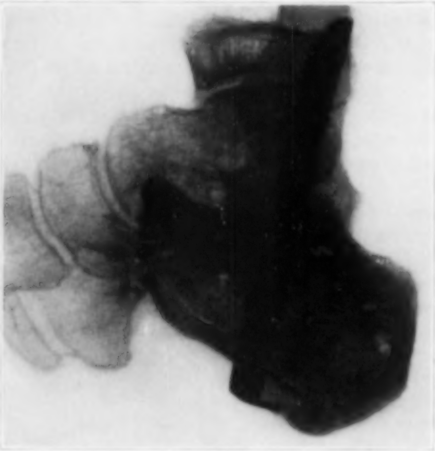

FIG. 4
September 30, 1948.

no signs of local recurrence or metastasis were discovered. Roentgenograms of the lungs were normal. The appearance of the foot was also normal (Figs. 7-A, 7-B, and 7-C). Only slight limitation of ankle movement was observed, but the gait was normal and the patient had no discomfort. The roentgenogram showed that the blood supply had been adequately reestablished, with a reabsorption zone along the lower border of the transplanted bone (Fig. 7-D). The patient was allowed to walk and has remained free of plaster since October 1949.

In December 1950 the patient's general condition was very good, and there was no evidence of local recurrence or metastasis. A roentgenogram of the lungs was normal. The patient said that he walked all day and played football without pain. The appearance of the foot was normal. The roentgenogram of the calcaneus showed a marked partial reabsorption of the inferior part of the transplanted bone (Figs. 8-A and 8-B).

When he was last seen, October 3, 1952, the patient was working as an assistant to a truck driver and was on his feet constantly.

The appearance of the foot was normal, with slight lateral limitations of motion. The roentgenogram (Fig. 9) shows increasing reabsorption of the transplanted bone.

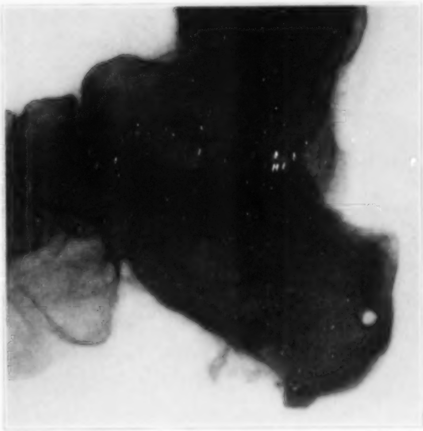

FIG. 5
April 1949.

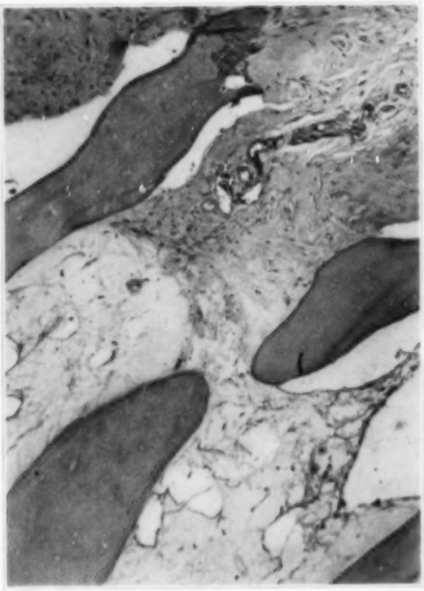

FIG. 6
Biopsy specimen from the transplanted bone.

SUMMARY AND CONCLUSIONS

Several conclusions may be drawn from this case and its course:

1. In view of the diagnosis of chondromyxosarcoma, either resection of the affected bone or amputation of the limb had to be decided upon.

2. Total resection of the calcaneus was preferred. Since absence of the calcaneus results in serious functional disability, we decided to replace the calcaneus by another which had been kept in the deep freezer.

3. It was possible to obtain a calcaneus removed two hours after death from a woman of forty-three, who had died of a disease of the nervous system.

4. The transplanted bone was perfectly tolerated. Avascular necrosis appeared laterally, increasing reabsorption of the transplanted bone.

5. Notwithstanding the partial reabsorption of the bone, the functional result was very good.

6. Deficiency of the blood supply may explain the process of reabsorption of the bone.

7. Reabsorption may also have been the consequence of trophic disturbances caused by the denervation.

8. Absence of pain can be explained by the denervation of the transplant.

9. The patient must be kept under further observation.

10. We consider this type of operation as an important step which may constitute a new trend in reconstructive bone surgery.

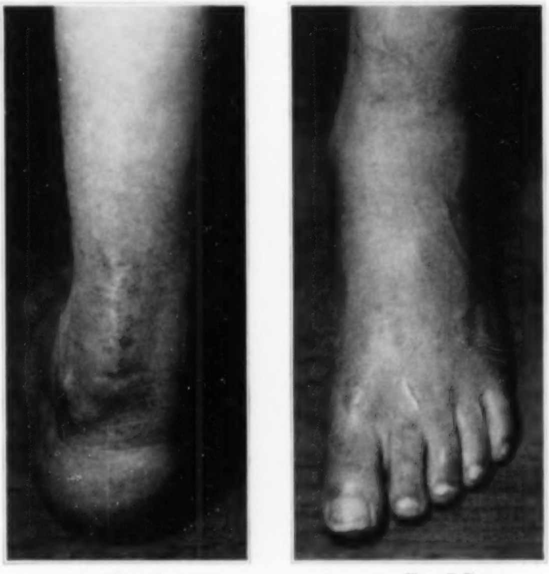

FIG. 7-A FIG. 7-B
September 13, 1949.

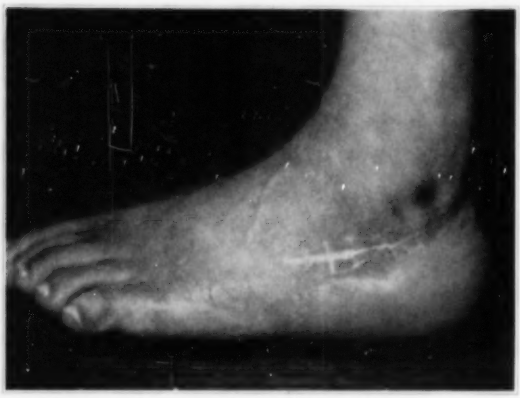

FIG. 7-C

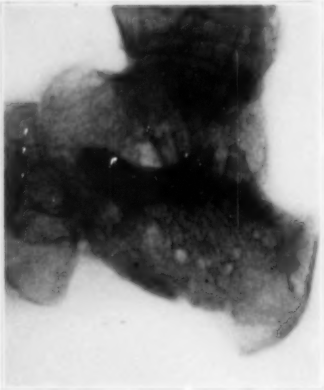

FIG. 7-D

September 13, 1949.

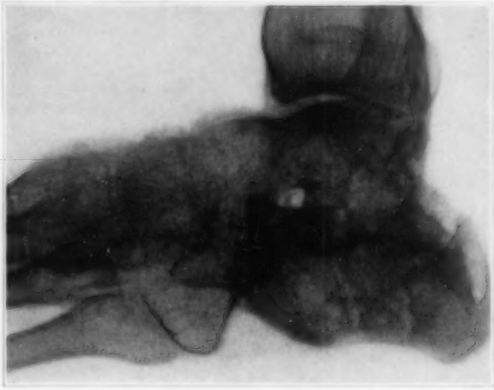

FIG. 8-A
December 1950.

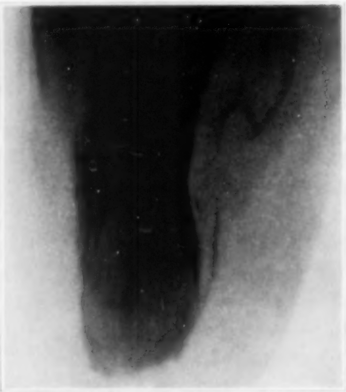

FIG. 8-B
December 1950.

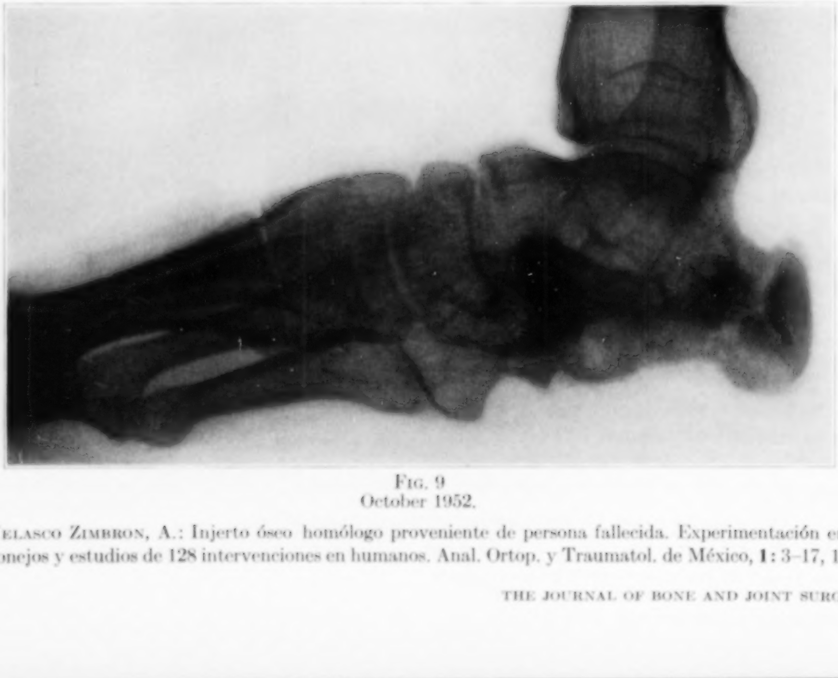

FIG. 9
October 1952.

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AN UNUSUAL OSSEOUS SEQUEL TO INFANTILE SCURVY

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The skeletal manifestations of scurvy occupy a prominent position in discussions of this disease in the medical literature, and the roentgenographic features have been carefully documented. Fractures of the calcified cartilage of the epiphyseal plates are sought in roentgenograms as a diagnostic sign and epiphyseal separations are recognized as a common associated phenomenon. Notwithstanding the often extensive skeletal involvement, the lesions heal promptly following adequate dietary treatment. Sequelae evident by roentgenogram have been described; they are restricted chiefly to thickening of the cortex of the tubular bones and central rarefactions of the round bones and epiphyses. Authors of textbooks of pediatrics, orthopaedics, and roentgenology, as well as of authoritative articles in medical journals, seem to be in agreement that permanent deformities resulting from scurvy are extremely rare. A case report is therefore submitted as an example of permanent skeletal deformity following infantile scurvy and probably resulting from it.

CASE REPORT

T. G. M. was born at term, on August 4, 1947, after an uncomplicated pregnancy and labor. He was a result of the eighth pregnancy of a mentally disturbed mother; his seven siblings were living and well. The family history was irrelevant except that the mother's mental condition resulted in irregular upbringing and neglect of all the children. The patient's diet had consisted exclusively of whole milk and water until his admission to the Hospital at six months of age. Vitamin-D concentrate was given beginning in the fifth month, but no vitamin C had been offered. He was said to have weighed nine pounds eight ounces at birth and weighed fourteen pounds seven ounces at the age of six months.

The child was first admitted to the Hospital on February 18, 1948, because of recurrent otitis media. For several days previously it had been noted that the child was irritable and fussy and on the day before admission the drainage from the ears was noted to be hemorrhagic. Culture of material from the ears prior to admission to the Hospital resulted in the isolation of hemolytic *Staphylococcus aureus*, non-hemolytic Streptococcus, and *Staphylococcus albus*. On the day of admission, a temperature elevation was noted for the first time.

Physical examination on admission revealed an ill-kept baby who was quite irritable and appeared chronically ill. The skin showed no lesions and was of good turgor. No tenderness or masses were identified in the abdomen. The tip of the spleen was thought to be palpable one finger's breadth below the costal margin. The liver edge was not palpable. The chest was symmetrical. No obvious rosary was detected initially. The lungs and heart were normal to physical examination. The right tympanic membrane was thick and grey, the external canal was oedematous and hyperaemic, but no exudate was seen. The left tympanic membrane was red and bulged slightly. Clotted blood was present on the sides of the canal. No exudate was seen. The tongue, palate, and pharynx were normal. No teeth were present. The gums were not remarkable and the remainder of the physical examination was normal. No mention was made of the extremities in the initial physical examination.

The child was started on a normal infant diet with the addition of vitamin C and D supplements in standard amounts and was given penicillin, 20,000 units intramuscularly, every three hours. The day after admission it was noted that the right leg and thigh were swollen and tender. Roentgenographic examination on that day revealed bilateral mastoiditis and a normal heart and lungs. The bones of the thorax were generally osteoporotic and the sternal ends of all the ribs were irregularly mineralized, spread, and cupped. The femora (Fig. 1) demonstrated on roentgenographic examination a large soft-tissue swelling over the right thigh. The distal femoral epiphysis on the right was displaced slightly posteriorly and there was evidence of early subperiosteal new-bone formation. All of the bones were diffusely osteoporotic. In contrast, the calcified cartilage at the ends of the shafts was relatively dense. A distinct subepiphyseal fracture was present at the medial border of the distal left femoral metaphysis.

The roentgenographic findings were considered characteristic of scurvy and adequately explained the

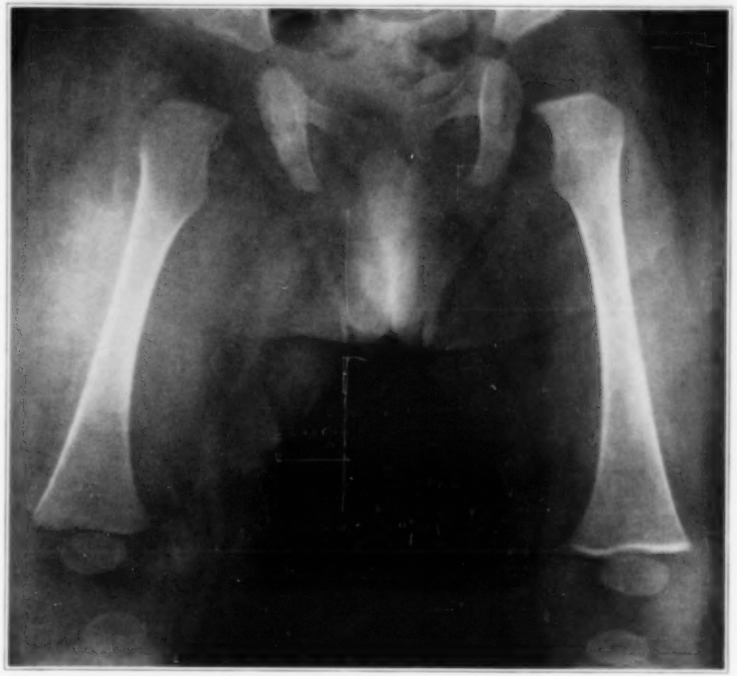

Fig. 1

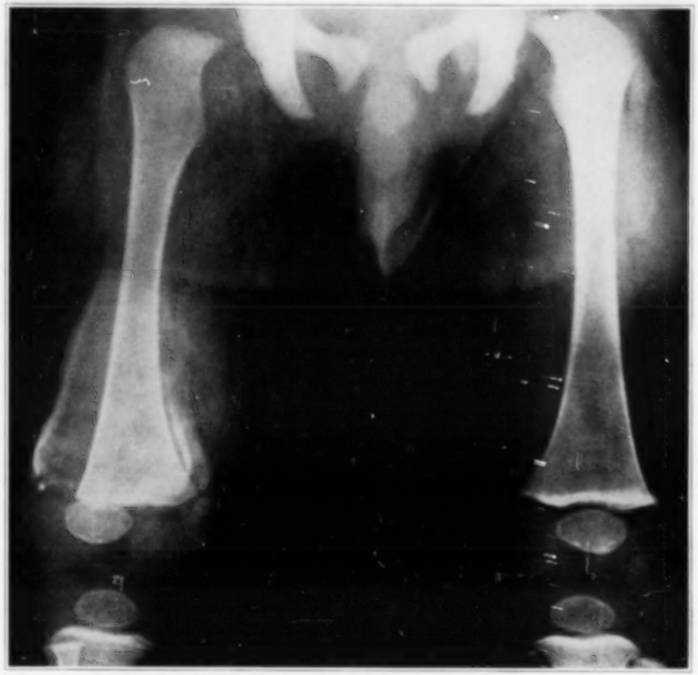

Fig. 2

Fig. 1: Roentgenogram made February 20, 1948, shows a case of classical scurvy. Note the soft-tissue swelling of the right thigh, and the faint calcifying subperiosteal hematoma around the distal portion of the femur. A faint "corner sign" is seen at the medial aspect of the left distal femoral metaphysis.

Fig. 2: February 28, 1948. The roentgenogram shows typical healing scurvy. The epiphyseal displacement is well demonstrated. (The vertical line through the epiphysis and the end of the shaft is an artifact.)

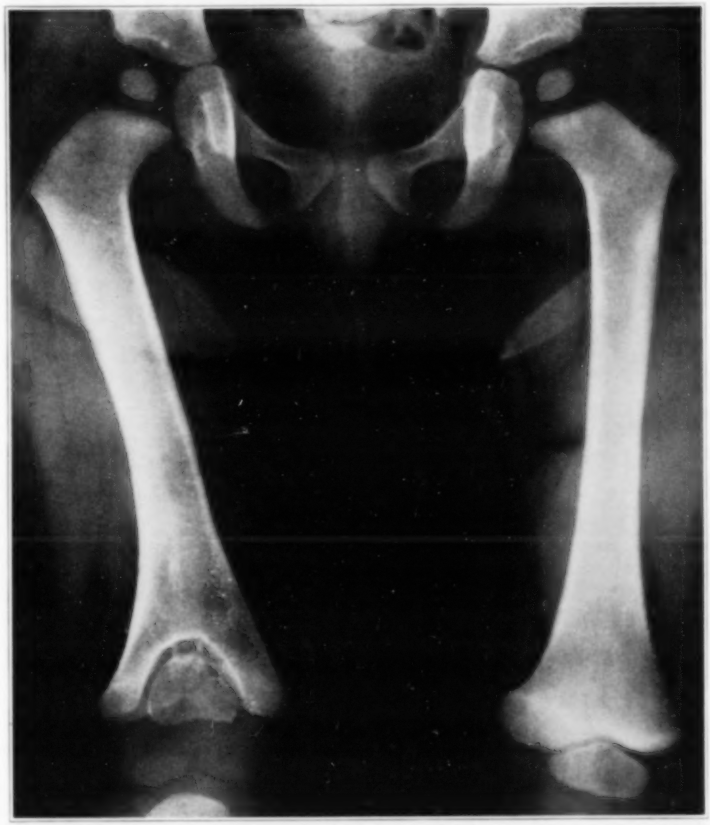

FIG. 3

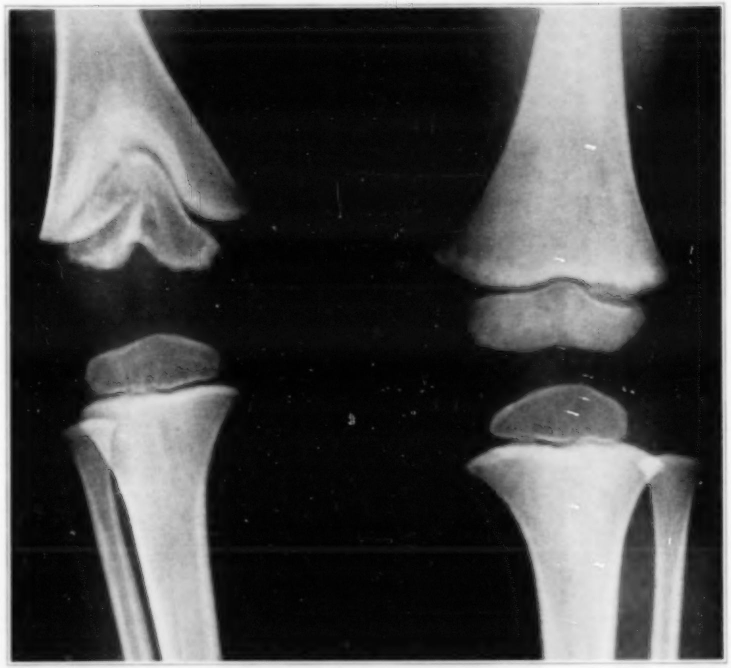

FIG. 4

Fig. 3: Roentgenogram made March 2, 1949, shows "ball-and-socket" effect in right femur. External cortical thickening is the only other sequel to the scurvy of a year earlier. There is a suggestion of bone fusion at the apex of the buried epiphysis.

Fig. 4: The roentgenogram made on June 11, 1951, showed further deformity with progressive growth. The disparity in size of all the osseous structures of the right limb is striking.

soft-tissue swelling of the right thigh. Previously the possibility of osteomyelitis, metastatic from a focus in the mastoid process of the temporal bone, had been considered. The child remained on penicillin therapy; the dosage of ascorbic acid was increased to 100 milligrams daily. The temperature dropped to normal within two days. Thereafter, the child's clinical course showed general improvement. The ear infection gradually subsided. The child was discharged February 28, 1948. The swelling had disappeared from the thigh, and the child was using both limbs freely and appeared very much improved. An examination of the long bones on the day of discharge (Fig. 2) demonstrated the characteristic bell-shaped subperiosteal calcification of healing scurvy in the distal end of the shaft of the right femur. Very slight changes of a similar nature were present at the distal end of the shaft of the right tibia. The remainder of the bones showed evidence of early healing scurvy.

Laboratory data: Hemoglobin varied between 9.6 and 12.0 grams per cubic centimeter, and 10,650 to 16,000 white blood cells per cubic millimeter. The highest count was obtained on admission. The differential count, on admission, revealed:

Polymorphonuclear leukocytes	51 per cent.
Eosinophils	1 per cent.
Lymphocytes	40 per cent.
Monocytes	8 per cent.

Subsequent counts showed a decrease in the polymorphonuclear leukocytes and a commensurate increase in the lymphocytes. Urinalysis was negative. A blood culture made on admission remained sterile. Hemolytic *Staphylococcus aureus*, coagulase negative, and hemolytic *Staphylococcus citreus*, coagulase positive, were obtained from the material draining from the ears. The calcium content of the serum was 11.6 milligrams per 100 cubic centimeters.

The child was seen subsequently in the Out-Patient Department on regular visits. Chronic and recurrent otitis media was diagnosed on each occasion. The last visit for this condition was on March 25, 1948, at which time the ear infection had subsided. The child was to return in six weeks, but did not return until February 28, 1949.

The chief complaint in February 1949 was that the child had been walking with a peculiar gait for three days. The right foot was believed to be dragging in comparison with the left. The manner of walking was described as "a peculiar ataxic gait" and it was thought that some tenderness was present in the right femur. Reflexes were active bilaterally. No discrepancy in the length of the lower extremities was observed. The child was referred to the Roentgenological Department for examination of the femora.

Roentgenographic examination of the femora revealed a surprising abnormality in the distal end of the right femur (Fig. 3). The right distal femoral epiphysis was impacted into the shaft of the femur in a "ball-and-socket" fashion. Appreciable shortening of the right femur was noted. Some subperiosteal new-bone formation was present along the lateral aspect of the shafts of both femora. No abnormalities were found in the region of the hip joints or in other bones of the lower extremities. The roentgenographic changes were thought to represent the results of fracture of the brittle epiphyseal plate during the active phase of this child's scurvy. Subsequent observations of this patient revealed progressive deformity with further embedding of the distal epiphysis of the femur in the shaft (Fig. 4). Clinically the child had no limp ordinarily, but did tend to fall and had intermittent "buckling" of the right knee. Flexion contractures developed in the right knee by March of 1950, but were adequately treated by application of a cast which was subsequently wedged straight. The recurrent ear infection has continued. At the last examination, in September 1951, the left lower extremity was one-half inch longer than the right. Full motion of the knee and hip was obtained, but considerable lumbar lordosis was noted.

DISCUSSION

As has been pointed out, deformity following metaphyseal and epiphyseal fractures in scurvy is extremely rare. Our patient appears to represent a *bona fide* case of deformity following fracture of the brittle calcified cartilaginous epiphyseal plate and its contiguous cartilage.

In the absence of vitamin C, osteoblastic activity is markedly suppressed and may cease. Calcification of cartilage continues, however, and the destructive phases of bone metabolism are apparently not affected. As a result, bone already formed prior to the development of vitamin-C deficiency loses its calcium content and becomes osteoporotic, while the calcified cartilaginous plates at the ends of the shafts of tubular bones and around the margins of epiphyses and round bones retain or even increase their density. This increase in density represents brittleness rather than strength. The trabeculae immediately beneath the calcified cartilaginous plates are irregular and bare of endosteal coating. Since the bone in this region is the most recently formed bone, considered from the standpoint of longitudinal growth, it is more defective than the previously normally formed bone and a structural weakness is present through this area. It is highly probable that the frequency of subperiosteal hematomata in scurvy is due to the fact that the most recently formed appositional (subperiosteal) bone is also deficient and hence the periosteal attachments are less secure than under normal conditions. The normal trauma of physical activity produces fractures through the zones of deficient osseous matter. In mild cases, the so-called "corner sign" is a manifestation of an incomplete fracture through the subepiphyseal region of a tubular bone. In more severe cases, when the fractures are complete, the epiphysis migrates from the longitudinal axis of the shaft until it is completely detached. Since the periosteum has its strongest attachment at the epiphyseal plate, which is detached together with the epiphysis, the epiphysis remains lined up to a periosteal envelope containing blood and surrounding the denuded shaft. Not infrequently, fractures occur through the calcified cartilaginous epiphyseal plate and are manifested by discontinuity of the dense line of this disc. In most cases it is probably just the calcified cartilaginous plate and a very small amount of the adjacent roentgenographically invisible cartilage, which is injured. We believe that the fracture in our patient must have extended through the entire thickness of the cartilage to the ossification center for the epiphysis.

It appears that the fracture extended through the layers of proliferating and resting cartilage, so that premature fusion of the ossification center for the epiphysis and the shaft at the site of fracture took place. The fracture site appeared to be approximately in the mid-portion of the epiphysis (Fig. 5). Since surrounding areas of the epiphysis were not interfered with, a cessation of growth did not occur peripheral to the actual area of fracture and subsequent fusion. Because of the central restriction of longitudinal growth, the central portion of the epiphysis remained attached to the shaft, while the more peripheral portions tended to grow at their normal rate. As a result, the epiphysis became embedded in the shaft. As the lateral portions of the shaft grew around it, distortion of the epiphysis took place. Abnormalities in the as yet unossified portions of the condyles could have been detected only if air-contrast studies of the joint space had been made, but it would appear highly probable that such abnormalities existed.

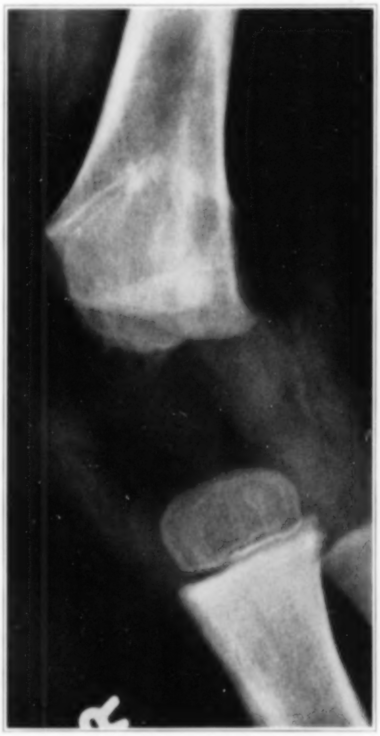

FIG. 5

Lateral roentgenogram, made on January 15, 1951, of the right knee showing site of bony fusion of epiphysis with shaft.

There seems little likelihood that any other condition could account for the abnormalities seen in this child. Pyogenic osteomyelitis was considered initially because of the chronic ear infection, but there was no evidence to support such a diagnosis. A blood culture was negative at the time of the initial complaint of swelling. It is possible that treatment of the ear infection with penicillin could have masked an osteomyelitis. However, the juncture of the epiphysis and metaphysis is an extremely unlikely site for osteomyelitis. The injury which produced the initial epiphyseal separation and presumably the epiphyseal fracture is not known and can seldom be recognized in scurvy. It is strange, in view of the frequency of epiphyseal fractures and actual fractures through the calcified cartilaginous plate, that deformities of this type are not seen more frequently following scurvy. In this patient, growth of the other long bones was normal, so that there was no reason to implicate an underlying abnormality of the resting and proliferating cartilage. It is much more likely that the injury which produced the epiphyseal separation, by a set of circumstances not completely understood, also caused a fracture through the resting and proliferating cartilage so that, with healing, premature union could take place between the bone of the epiphysis and of the metaphysis.

SPONTANEOUS FRACTURES IN PARAPLEGIC CHILDREN

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In a compilation of causes of pathological fracture[5], atrophy of bone is usually included. Osteoporosis, from whatever cause, is admittedly a factor in susceptibility to traumatic stresses, as for example the stress of vertebral compression in senility and

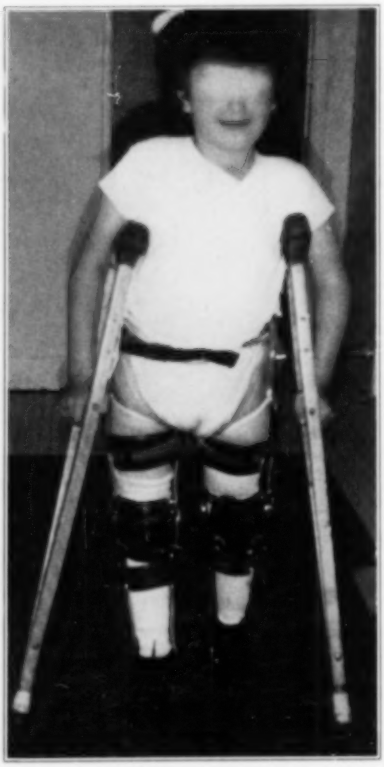

Fig. 1-A

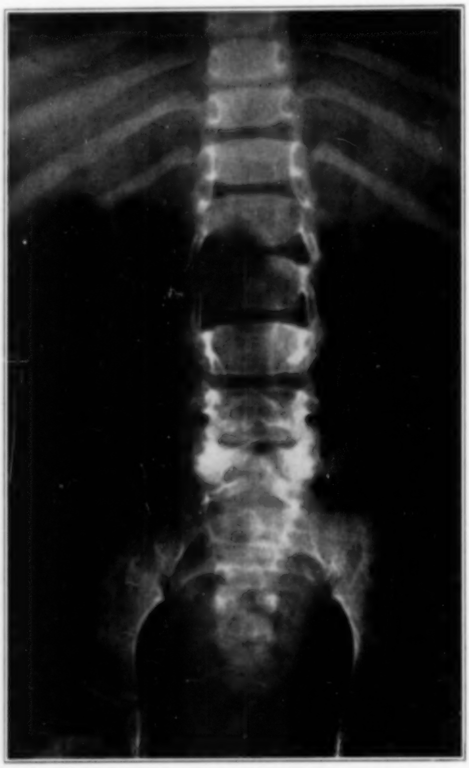

Fig. 1-B

Fig. 1-A: Case 1, A. G., shown in braces several weeks before the last fracture.

Fig. 1-B: Anteroposterior view of the lower portion of the spine in Case 1, showing spina bifida in the lumbar segment.

* Dr. R. K. Lippmann, Surgical Director.

postmenopausal states. Fractures resulting from only minimal trauma have been encountered in atrophic limbs such as may follow extensive poliomyelitis. The frequency and multiplicity of pathological fractures in the lower extremities in children who are paraplegic as a result of spinal-cord interruption have not been accorded proper emphasis.

This report is concerned with the incidence of lower-extremity fractures in paraplegic children with sensory disturbance. Papers dealing with adult paraplegics have mentioned the complication of susceptibility to pathological fractures, but their occurrence was regarded as infrequent. In one series[1], it occurred in five out of a group of forty-eight patients who were classified as almost completely non-ambulatory. In the same series, none occurred in a group of eight adult paraplegics who were ambulatory. In another study[4], sixty-two adult patients were reported, of whom twenty-three had soft-tissue ossification about the hips or knees, or both, but no mention was made of occurrence of fracture. No reference was found in the literature to the incidence of fractures in paraplegic children.

Since pain is diminished or removed by virtue of the spinal-cord interruption primary to the paraplegic state, the exact mode as well as the time of fracture is often difficult to identify. In the cases to be reported, the fractures were usually discovered by nurses when there was unexplained swelling and distorted appearance of the affected limbs. Commonly, there was an associated increase in local skin temperature, which suggested cellulitis before the true nature of the condition was revealed by appropriate roentgenographic studies. The following two case reports will illustrate the course of events in paraplegic children undergoing rehabilitation therapy at Blythedale.

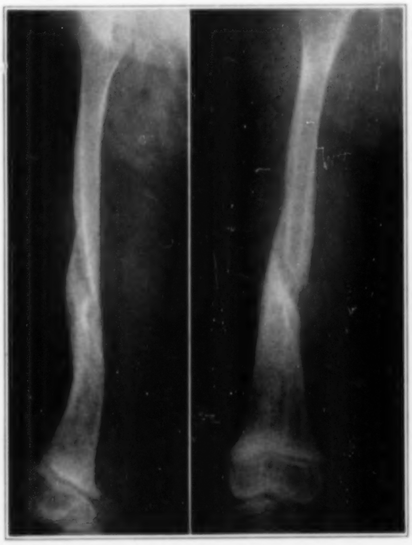

Fig. 1-C

Fig. 1-C: Anteroposterior and lateral views of the right femur, made on November 19, 1949. The evidences of previous healed fractures are shown. The most recently healed fracture at the juncture of the middle and lower thirds occurred five months previously.

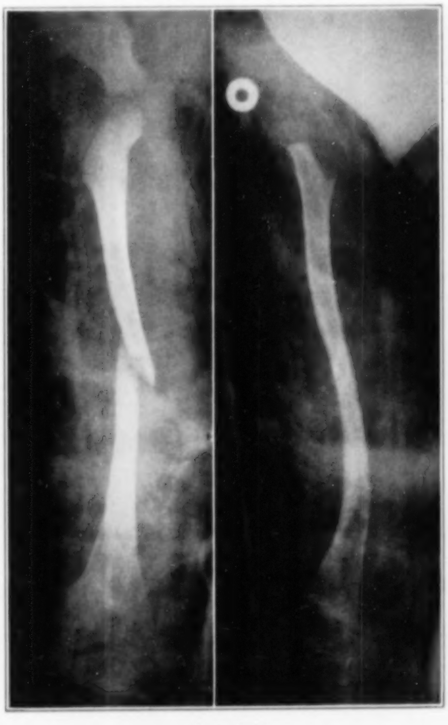

Fig. 1-D

Fig. 1-D: Anteroposterior and lateral roentgenograms of the right femur, made on August 28, 1951, with the plaster cast in place, demonstrated the fourth fracture in the mid-shaft. The attenuated state of the bone is well shown. The sites of the earlier fractures had been remodeled, but some anterior bowing of the lower third of the femur persisted.

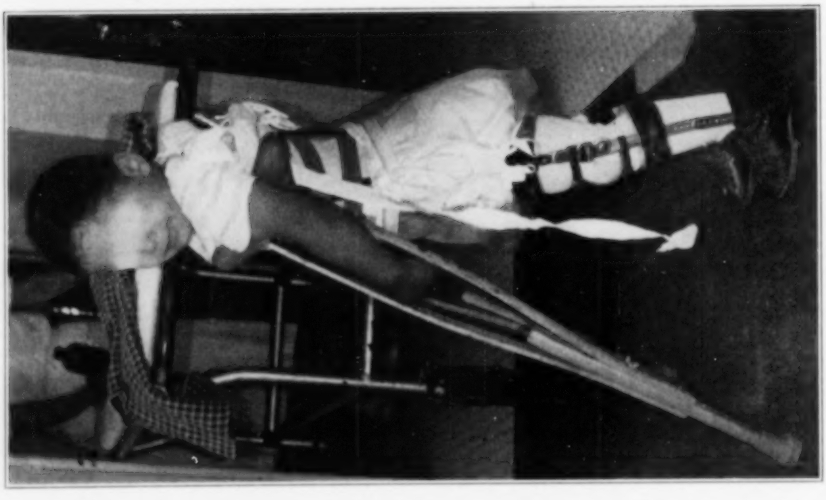

Fig. 2-A

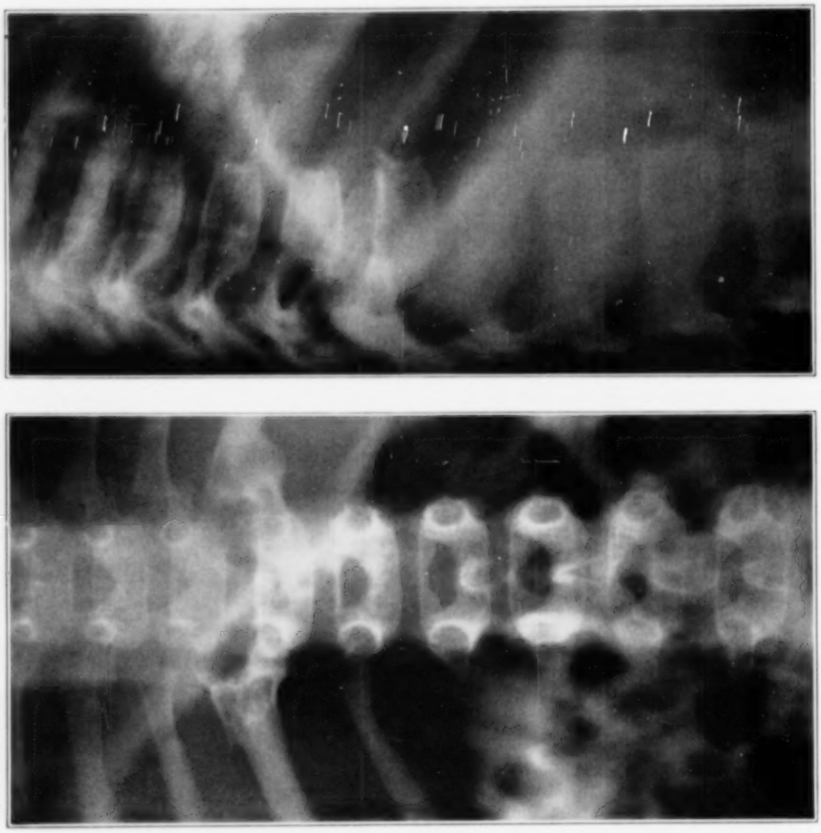

Fig. 2-B

Fig. 2-A: Case 2, H. J. Photograph taken several weeks before the most recent fracture, showing the patient in braces.

Fig. 2-B: Anteroposterior and lateral views of the thoracolumbar portion of the spine, showing the traumatic lesion at the tenth and eleventh thoracic vertebrae eleven months after injury and after laminectomy.

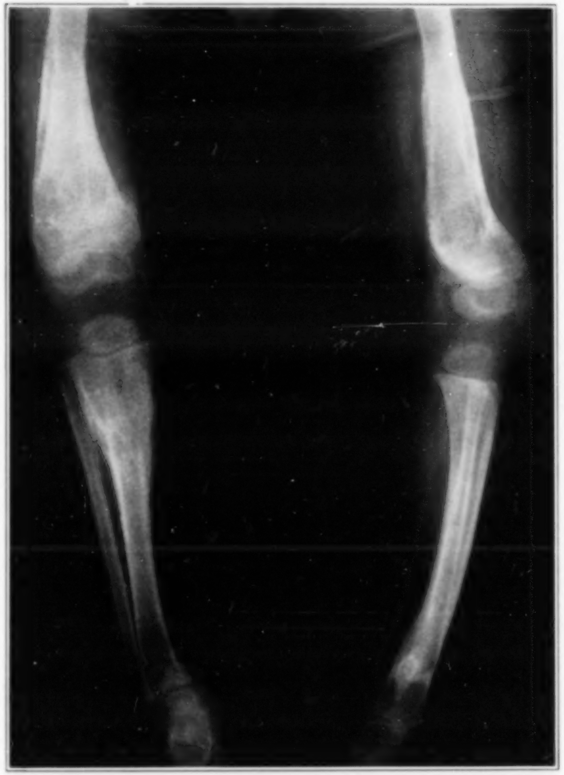

FIG. 2-C

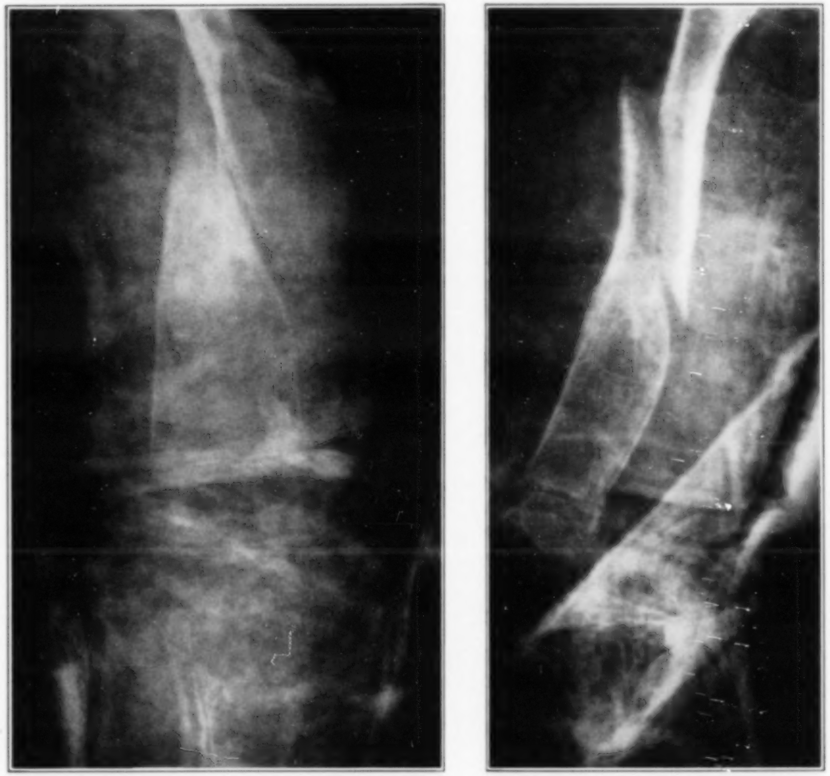

FIG. 2-D

Fig. 2-C: Roentgenograms showing both lower extremities on November 8, 1950. Evidences can still be seen of the healed fractures in the distal ends of both femora, proximal end of the right tibia, and the distal end of the left tibia. In addition, there is a small area of soft-tissue ossification along the medial aspect of the lower end of the right thigh.

Fig. 2-D: Anteroposterior and lateral x-rays of the lower half of the right femur taken through plaster on September 15, 1951, showing the most recent fracture. The fracture line is long and oblique, with moderate medial-lateral malalignment.

CASE REPORTS

CASE 1 (Fig. 1-A). A. G. was born on June 23, 1944, with spina bifida and meningomyelocele (Fig. 1-B). The spine defect was closed operatively, but paraplegia of both lower extremities, associated with sensory lack and bowel and bladder incontinence remained unchanged. She was fitted with braces for the lower extremities in September 1947 and was admitted to Blythedale in December 1947 for rehabilitation. Beginning in January 1948, she was able to stand with the aid of crutches. By June 1948, she was able to make effective swinging movements with her crutches, using the tripod pattern of ambulation. Her first fracture occurred in November 1948, eleven months after mobilization, when deformity and swelling of the right thigh were noted in bed. Excellent callus formation followed about six weeks of plaster immobilization and she was returned to her braces. By the middle of January 1949, she was restored to her former proficiency in crutch ambulation. In February 1949, another fracture of the right femur was discovered while she was in bed. She remained in plaster until June 1949, when union was demonstrated clinically and by x-ray. Within days of the removal of the plaster cast and before she had been permitted out of bed, a third fracture of the same femur occurred without known provocation. Traction was applied until the latter part of July 1949; after that she was again given braces but was kept in bed. Slowly and painstakingly, the child was again taught crutch walking. Considerable resistance had to be overcome because of impaired morale following her prolonged inactivity, but in the ensuing months she again hopped about like a veritable "jitterbug", going everywhere by her own propulsive efforts. The most recent fracture (Fig. 1-D), the fourth in almost three years, following two years of regular daily crutch ambulation, took place on August 27, 1951, while she was in bed. There had been no trauma other than pushing herself about in bed.

CASE 2 (Fig. 2-A). H. J. was born August 4, 1947. He sustained a fracture-dislocation of the tenth thoracic vertebra (Fig. 2-B) with resulting paraplegia, loss of sensation, and bowel and bladder incontinence, after a fall down a flight of stairs on January 5, 1950. Early operative intervention failed to restore motor or sensory integrity. About the middle of March 1950, "cellulitis of both thighs" was recorded in the hospital abstract. On April 14, 1950, roentgenograms revealed "extensive subperiosteal hemorrhage with calcification in the lower halves of the right and left femoral bones surrounding the diaphyses". The true significance of these changes was not immediately realized; scurvy was considered, but was excluded by determinations of the vitamin-C level. On May 9, 1950, the thigh indurations had subsided, but the left leg and foot were swollen. On May 24, 1950, the right leg was indurated. X-ray studies revealed healed transverse fractures of the left tibia. Shortly thereafter, all of the previous films were properly re-interpreted as showing fractures wherever "cellulitis and induration" had been diagnosed previously. At least four areas (Fig. 2-C) had had

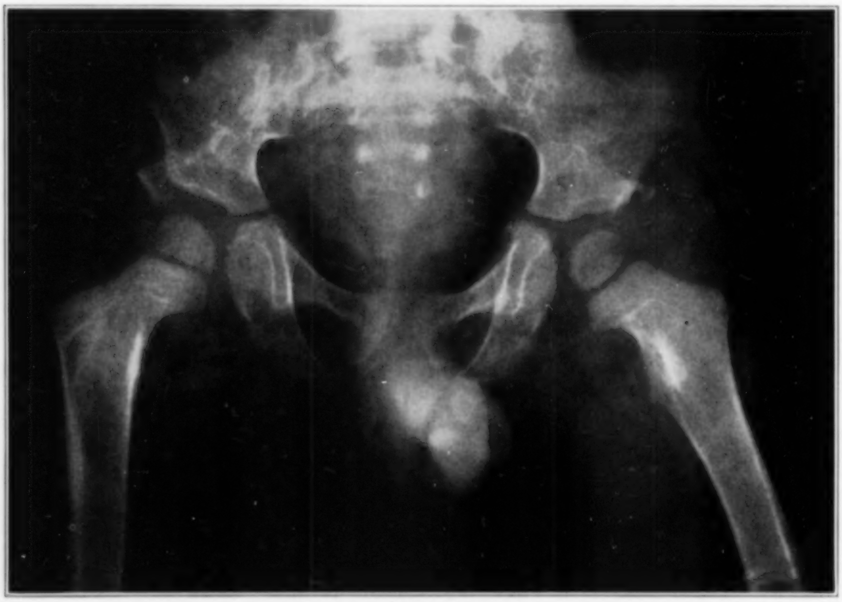

FIG. 2-E

Fig. 2-E: Anteroposterior view of the pelvis, made on November 8, 1950, showing moderate ossification about both hips, particularly on the right.

spontaneous fractures resulting from no more trauma than movement in bed. The child was admitted to Blythedale on November 3, 1950, for rehabilitation. On January 15, 1951, he was given braces for the lower extremities which were attached to a spinal brace and, by February 1951, he was standing in parallel bars. He made rapid progress in crutch ambulation, using a swinging gait. Satisfactory advances were being made in this program and the child was out of bed most of the day. On September 13, 1951, before applying his braces in the morning, nurses noted swelling and increased warmth of the right thigh. Clinically he exhibited false motion and x-rays revealed an oblique torsional fracture of the lower half of the right femur (Fig. 2-D). His initial fractures had developed after two months of bed rest following the onset of his paraplegia and before he had been out of bed. His last fracture occurred after eight months of daily mobilizing crutch-walking activity, but was sustained while he was in bed.

In the patients described, paraplegia was present at birth in one case (Case 1), and occurred in the third year in the other (Case 2). There seemed to be no orderliness or predictability in the incidence of fracturing. In Case 1, fractures occurred at one time after eleven months of ambulation, at another time after two years of crutch walking, and still another time after only one month of ambulation. In Case 2, the first fracture occurred after two months of bed rest, following the traumatic incident which led to the paraplegia. The most recent fracture in this patient occurred eight months after he was allowed bracing and mobilization. The fact that both children had attained a degree of rehabilitation which permitted tripod crutch ambulation in lower-extremity braces is significant. This is especially so, since activity and mobilization in braces over considerable periods of time had failed to prevent lower-extremity fractures following such simple manoeuvres as a child turning and lifting himself in bed.

Osteoporosis has been described as a disturbance in bone-tissue metabolism [2, 3], the defect arising either in the osteoblasts or in the bone matrix. Disuse osteoporosis is usually confined to the affected portions of the bony framework. It is conceded that osteoblastic activity is influenced by and responds to mechanical strains and stresses. When this natural stimulus is removed, as in fixation for fracture therapy or disuse of an extremity for other causes, decreased osteoblastic function follows. The obvious therapy for disuse atrophy would be mobilization.

Abramson, reporting on adult paraplegics, was of the opinion that ambulation by means of crutches and braces constituted a form of intermittent pressure sufficiently similar to the normal physiological stimulus of walking to maintain and restore bone integrity. He argued that, by preventing bone atrophy through this measure, such complications as urinary calculi, soft-tissue ossification, and fractures could be prevented. His experience with adult paraplegics confirmed this contention. The difference in the incidence of complications in paraplegic adults, as compared with paraplegic children, appears due to the greater uncontrolled activity of the younger age group during confinement in bed. Despite the completeness of the paralysis, motor as well as sensory, and the accompaniment of urinary and fecal incontinance, in neither of the two children here reported did decubitus ulcerations or urinary calculi develop. One of the children (Case 2) demonstrated minor soft-tissue ossifications about the region of the hips (Fig. 2-E) and on the medial aspect of the distal end of one thigh (Fig. 2-C).

It may be argued that mobilization remained ineffective as a fracture preventative because ambulation was on braces, which eliminated some of the stresses present in normal free activity. On the other hand, the possibility of diminished or absent neurotrophic factors because of the interrupted nerve pathways must also be considered. At Blythedale, during a comparable period, not a single fracture occurred in bed in correspondingly handicapped children with paralytic conditions after poliomyelitis, whose out-of-bed activities were also possible only with extensive bilateral lower-extremity bracing. It would appear that the obvious difference between these two groups of children lay in the absence of sensation in the group with spinal-cord lesions, so that traumatic factors were allowed to extend beyond the limits of pain. It is also interesting that not a single fracture which occurred in the paraplegic children developed while they were weight-bearing in braces. All of the fractures occurred in bed, when the children were not wearing external protective devices. The general experience has been that these fractures healed promptly, notwithstanding the fact that the necessary immobilization contributed to the osteoporosis already present. The considerable frequency of fractures in paraplegic children, with its attendant periodic interruption in rehabilitation therapy, constitutes a vicious situation.

Prophylaxis against such spontaneous fractures in the young paraplegic patient is of utmost importance. Since the fractures occurred while the children were in bed, preventive measures would have to be directed either (1) toward changing the manner of handling by nurses and attendants during routine nursing procedures or (2) to the employment of protective bed splints. Continuous splinting, while theoretically desirable, may engender breakdown of skin and additional osteoporosis in limbs devoid of sensation. It is the safer alternative to orient nursing and attendant personnel to the danger of fracture and to urge cautious handling in the manipulations required by daily routine bed care.

CONCLUSIONS

1. Bone atrophy is an unavoidable concomitant in paraplegia.

2. Ambulation with crutches and braces does not restore bone integrity to a degree sufficient to eliminate the danger of spontaneous fractures, at least in children.

3. Paraplegic children exhibit considerably greater uncontrolled activity in bed than do adult paraplegics with similar handicaps.

4. Spontaneous fractures occur frequently in paraplegic children during rest.

5. Nurses and attendants administering routine daily bed care should be cautioned to exercise gentleness.

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OBSTETRICAL PARALYSIS WITH DISLOCATION OF THE SHOULDER

A Case Report *

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The purpose of this paper is to present a case of dislocation of the shoulder seven months after an obstetrical paralysis.

The patient was born at New York Hospital on February 15, 1951; he weighed 9.5 pounds at birth. The delivery was difficult because the left shoulder was lodged against the pubic arch, making it necessary to apply downward traction to the head. Examination immediately following birth revealed an obstetrical paralysis of the left upper extremity with no active motion of the shoulder, fair flexion and extension of the elbow, absence of extension of the wrist and hand, and normal flexion and grasping power of the hand. Otherwise the infant was a healthy colored male. Roentgenograms of both shoulder girdles showed no bone or joint abnormality (Fig. 1).

Treatment consisted in pinning the sleeve of the left upper extremity to the head of the crib to maintain the shoulder in 90 degrees of abduction and 90 degrees of external rotation. Upon the patient's discharge from the nursery, the mother was instructed to exercise the extremity passively with each diaper change.

At one month of age the patient was seen in the Orthopaedic Clinic, where slight improvement was noted in the function of the shoulder and elbow joints, and marked improvement in the wrist-drop. Again at this time there was no evidence of dislocation of the shoulder. At five months of age there was additional slight improvement in the motor function of the left upper extremity, and the shoulder joint was normal to examination.

At six months of age the patient had an obvious dislocation of the left shoulder. The mother gave no history of trauma during the interim, and was unaware of any change in the function of the arm.

Examination at this time revealed the humeral head to be beneath the coracoid process, with redundancy of the soft tissues about the shoulder joint. No motion was demonstrable between the humeral head and the scapula, and attempted motion was painless. The arm was held in 45 degrees of abduction, and attempted adduction produced marked "winging" of the scapula. Flexion of the elbow was normal, but extension was limited to 150 degrees. Pronation was normal, but the forearm lacked 45 degrees of full supination. Flexion of the hand was normal, but active extension of the wrist lacked 15 degrees of reaching the neutral position. Roentgenograms revealed an antero-inferior dislocation of the shoulder joint; retarded development of the proximal humeral epiphysis (Fig. 2); and winging of the scapula upon adduction (Fig. 3).

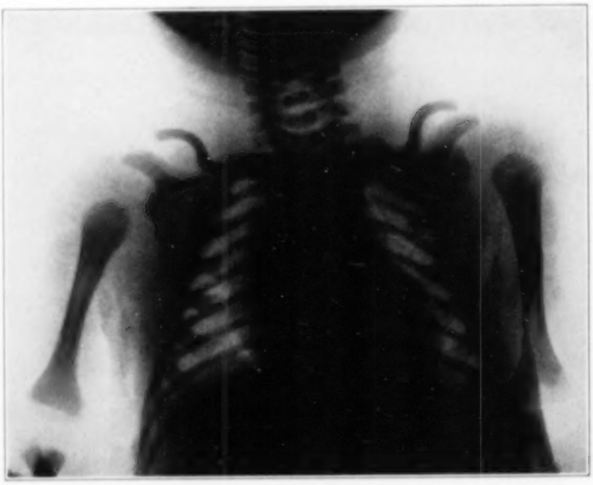

FIG. 1

Roentgenogram of both shoulders made on the day of birth, showing no dislocation, fracture, or joint abnormality.

The patient was hospitalized because it was believed to be imperative to reduce the dislocation, to attempt to obtain normal motion, to prevent bony deformity of the humerus, and to improve the appearance of the shoulder joint. Closed reduction under general anaesthesia was attempted gently but failed, and an open reduction was done on August 31, 1951. The shoulder joint was approached through an anterosuperior incision. The three muscle origins on the coracoid process were reflected inferiorly to expose the dislocated humeral head, which was still within the joint capsule. The subscapularis tendon was not identified. The glenoid cavity was empty, and no rent in the joint capsule or musculotendinous cuff was noted. Reduction was not possible until the capsule was opened longitudinally and the tendon of the long head of the biceps muscle, which was bow-stringed tightly across the head, was incised. The intra-articular portion of the biceps tendon was resected and the free distal end was anchored in the intertubercular groove. No attempt was made to plicate the capsule, which was closed along the line of incision. The reduction was stable, and was maintained by a Velpeau dressing. Roentgenograms revealed the reduction to be complete.

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* This study was aided by a grant from the Marie Heye Clemens Fund, Inc.

One month after operation immobilization was discontinued and active motion of the shoulder joint was encouraged. Two months after operation roentgenograms showed that the humeral head had remained reduced (Fig. 4), and passive-motion exercises were carried out both by the Physical Therapy Department and by the mother. When the patient was last seen, six months after operation, the left shoulder appeared normal and there was active abduction to 45 degrees. Passively, abduction was 90 degrees; internal rotation and external rotation were complete. The mother commented that since the operation the child had used the entire left upper extremity much better.

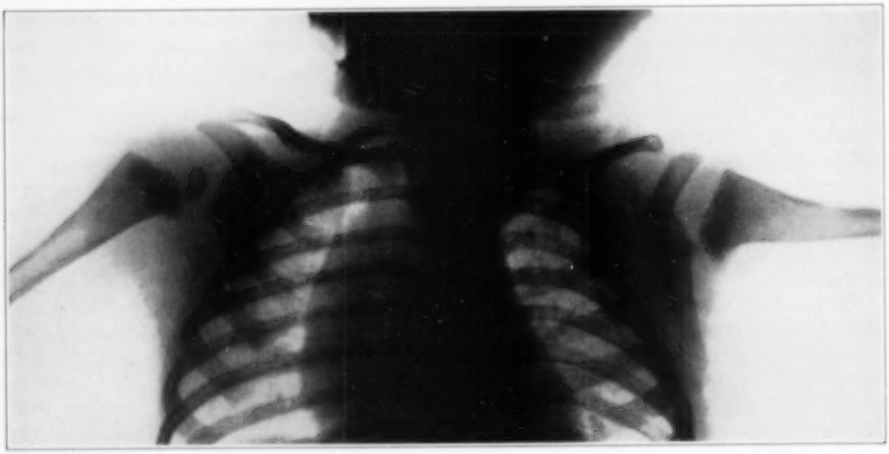

Fig. 2

Roentgenograms made six months after birth of both shoulders in abduction, showing an antero-inferior dislocation and retarded development of the proximal humeral epiphysis of the left shoulder.

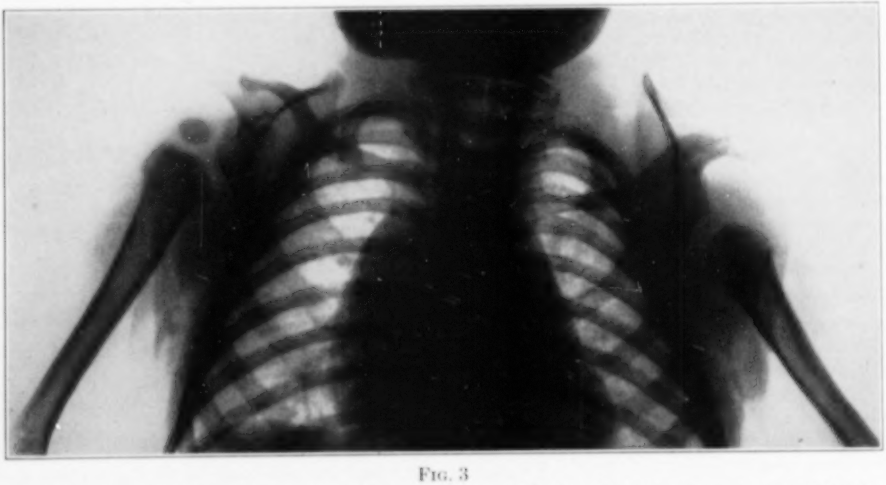

Fig. 3

Roentgenogram of both shoulders in adduction, six months after birth, showing winging of the left scapula.

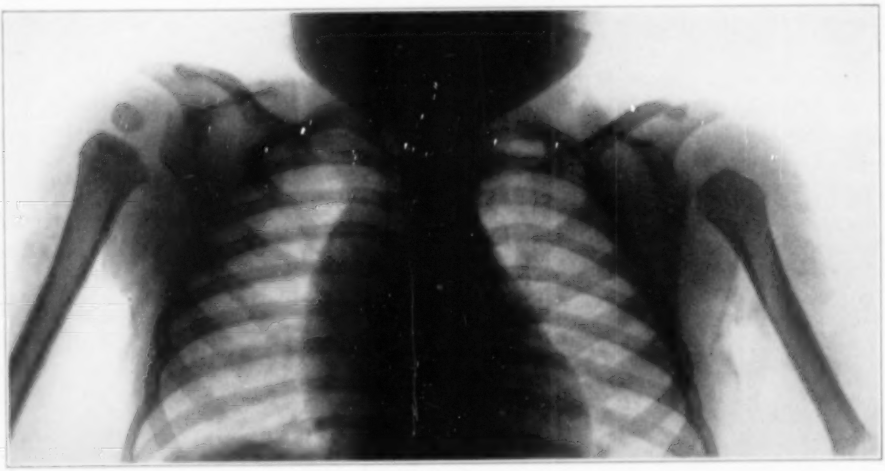

FIG. 4

Roentgenogram of both shoulders eight months after birth and two months after an open reduction, showing the left shoulder to be well reduced.

DISCUSSION

A review of the periodical literature and the textbooks has failed to reveal previous mention of subcoracoid dislocation of the shoulder joint in association with brachial-plexus palsy. Sever reported 1,100 cases of obstetrical paralysis in 1925, mentioning posterior subluxation of the shoulder joint, as well as subluxation and dislocation of the radial head, but not the occurrence of anterior dislocation of the shoulder. Boorstein reported 211 cases of obstetrical paralysis in 1930, and Wolman 125 cases in 1948, without the occurrence of dislocation of the shoulder.

The combination of obstetrical paralysis and anterior dislocation of the shoulder is probably not, however, as infrequent as suggested by this review of the literature, since the extensive paralysis of the musculature about the shoulder joint, as well as the maintenance of the joint in abduction and external rotation during treatment, provide an excellent combination of etiological factors.

Although dislocation and subluxation of the paralytic shoulder in patients with poliomyelitis is not an unusual finding, these conditions apparently rarely occur in obstetrical paralysis. The reason for this discrepancy is due to the degree of paralysis, the palsy following poliomyelitis usually being much greater than that of obstetrical paralysis of the shoulder. In obstetrical paralysis of the Erb's type the subscapularis, teres major, and latissimus dorsi muscles maintain their innervation and, in part, are responsible for the subsequent fixed deformity of adduction and internal rotation of the shoulder. It is believed, therefore, that, if in such cases dislocation of the shoulder is to occur, it must occur before the establishment of the adduction-internal rotation contracture.

It was suggested by some that the dislocation described herein may have occurred during delivery and was subsequently missed. The initial roentgenograms (Fig. 1), and the fact that several different examiners saw the patient, prove that the dislocation was not present at birth. In addition, Truesdell stated that the occurrence of traumatic dislocation of a normal joint in the newborn has not yet been conclusively demonstrated. It is believed that the most likely cause of the dislocation was the severe muscle weakness about the shoulder, which permitted the displacement to occur when the joint was placed in abduction and external rotation.

The occurrence of a shoulder dislocation in this patient leads one to question the premise that, in order to relieve traction on the brachial plexus and to place the paralyzed muscles at rest, the shoulder should be immobilized in the usual position of 90 degrees of abduction and 90 degrees of external rotation. It would appear preferable, should this form of treatment be elected, that abduction should not exceed 80 degrees and external rotation should not exceed 45 degrees. Furthermore, this case serves to emphasize the fact that overzealous passive manipulation in these planes may add further damage to an area already subjected to severe trauma.

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SUCTION-SOCKET PROSTHESIS FOR A HIP-DISARTICULATION AMPUTEE*

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This report presents the case of an amputee with a disarticulation through the hip joint who was successfully fitted with a suction-socket prosthesis. The case history contains several unusual and thought-provoking aspects.

The patient, a white male machinist, thirty-three years old, sustained multiple injuries to the right thigh in 1939. Osteomyelitis of the femur resulted from the injuries. Because of the extensive destruction of the shaft, the greater trochanter, and the neck of the femur, disarticulation at the hip joint was decided upon. In carrying out the amputation, the surgeon preserved as much soft tissue as possible, carefully dissecting the femur out from the surrounding tissues.

The patient made an uneventful recovery from this amputation, and was subsequently fitted with a conventional type of prosthesis. Because the stump was flabby and soft and because there was no bony structure to insert into the thigh socket, he was unable to walk with any degree of comfort with this prosthesis. He found that he slipped forward off the posterior rim of the socket and that irritation of the ischial tuberosity and of the adductor tendons at their point of origin on the pelvis was quite severe. Because of dissatisfaction with this type of prosthesis, the patient tried without success various modifications of the socket. He required not only the additional support of a cane but a lock at the pelvic joint for stability.

Eleven years later, the patient was fitted with a suction-socket prosthesis. The socket of this prosthesis was constructed with the same shape as that of the usual suction socket. The ischial seat was maintained beneath the ischial tuberosity by the firm hold of the socket upon the fleshy stump. The stump measured six inches in length when relaxed; but, when it was contracted into a firm mass of muscle tissue, it measured about four inches. The muscles had become attached to each other by scar tissue, so that there was active flexion and extension of the stump if one grasped the muscles with his hands.

After being fitted with this suction-socket prosthesis, the patient was able to walk farther than he had at any previous time. He discarded his cane and learned to walk with an almost normal gait. He regained active flexion and extension of the prosthesis at the hip joint, because of the fixation of the skin and muscles to the side of the socket by the suction exerted upon the distal end of the stump. He now stands eight hours a day on the prosthesis while at work, and usually an additional four or five hours at night in his hobby shop. He walks about one half mile a day. No circulatory changes in the stump or irritation of the ischial tuberosity have developed. He wears the prosthesis seven days a week, and usually removes it for four or five hours on Sunday afternoon.

* Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

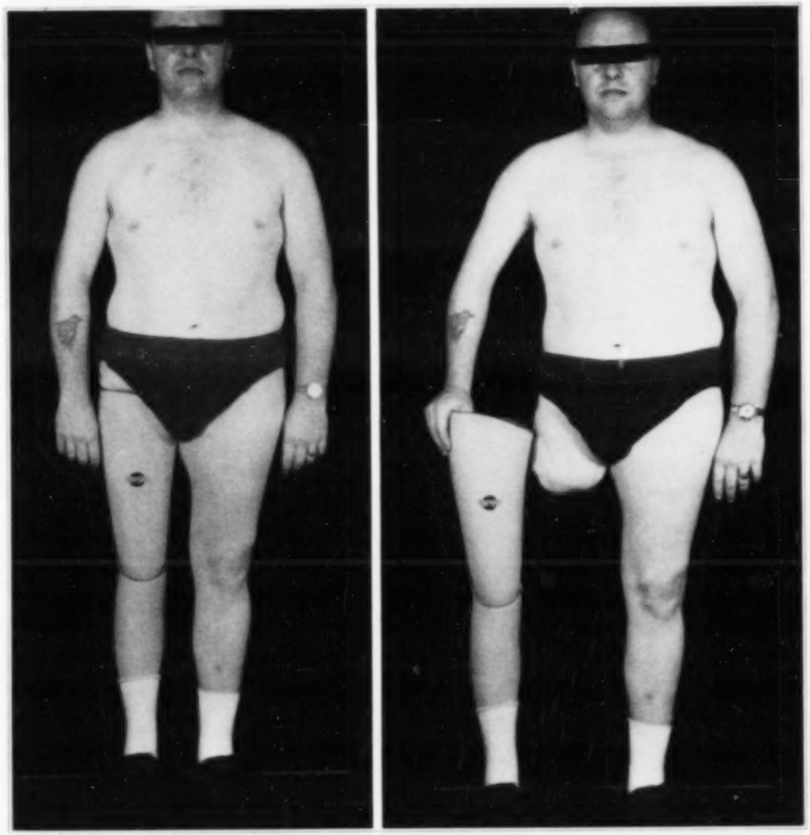

FIG. 1-A FIG. 1-B

A suction-socket prosthesis has been fitted to a fleshy stump without a femur.

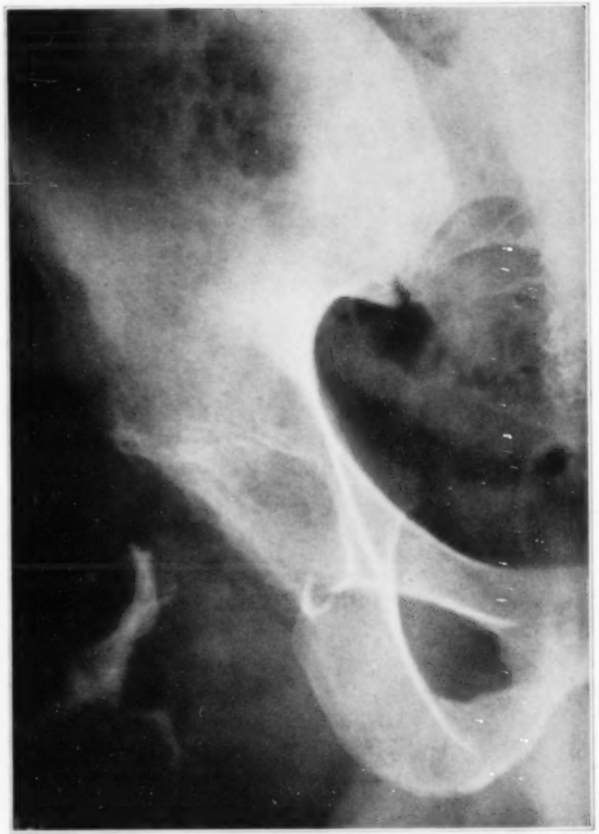

FIG. 2

Roentgenogram of the stump shows the absence of the femur.

This patient is unusual in our experience with amputees with disarticulation at the hip joint. The value of preserving soft tissues in above-the-knee amputations is shown in the management of this case, and the concept of dissecting diseased bone from soft tissue, rather than that of performing a transverse type of amputation, is demonstrated. It seems wise, in view of our experience with this case, to consider the preserving of all soft tissues, even though the stump of the femur might be only one inch or less in length. Perhaps in cases where a high-thigh amputation is indicated, one should consider technical methods of salvaging as much of the soft tissue as possible, in order that the patient might later be fitted with a satisfactory suction-socket prosthesis.

This case demonstrates the possibility of the conversion of an endoskeletal system to an exoskeletal system by the fixation of the skin and subcutaneous tissues to the prosthesis. This restores the motor power of the stump in exactly the same way that the crustacean activates his exogenous skeleton. We have found in this patient that the presence of the femur is not necessary to fit a suction socket so that the ischial seat comes to rest beneath the ischium upon weight-bearing. It is more important to design the socket in such a way that, upon weight-bearing, the contracted muscle mass is properly positioned on the ischial seat beneath the ischial tuberosity.

FUNCTIONAL HYPEREXTENSION BACK BRACE

BY ODON F. VON WERSSOWETZ, M.D., NASHVILLE, TENNESSEE

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The object of a functional back brace is not to support the body load but to maintain, as normally as possible, the postural alignment of the body. This should result in the restoration of the weight-bearing stability of the spine, combined with the balanced transmission of the forces of gravity and weight.[1] In cases in which, because of muscle weakness or imbalance, the spinal column shows a forward inclination, a mechanical support may be required. Most of the available spinal braces are too rigid and act as gutter splints. Some do incorporate the three-point pressure principle, but often they cause great discomfort to the patient. These braces require two stabilizing points on the anterior body surface, which are the thoracic cage at the upper end and the symphysis pubis at the lower end. From practical experience, it has been found that some patients cannot stand the pressure necessary to stabilize these braces firmly. If only a moderate pressure is used, slipping will occur. Also, these braces may be uncomfortable in the sitting position in which, because of the altered inclination of the pelvis, there is a shortening of the distance between the symphysis pubis and the chest.

To alleviate some of these discomforts while preserving the fundamental principles of three-point pressure, the functional hyperextension back brace (Fig. 1) was used successively on several patients with deformities resulting from poliomyelitis. Basically, this brace is constructed on the same principle as the Williams back brace. It consists of a chair-back brace, which clears the inferior angles of the scapulae. To this is added an inverted U-shaped frame which pivots on both of the upright bars. The apex of the U-shaped frame is expanded into a plate, padded with sponge rubber, which is placed over the

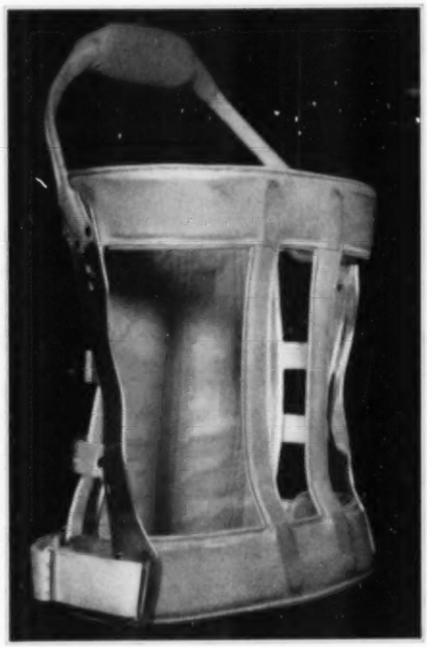

FIG. 1

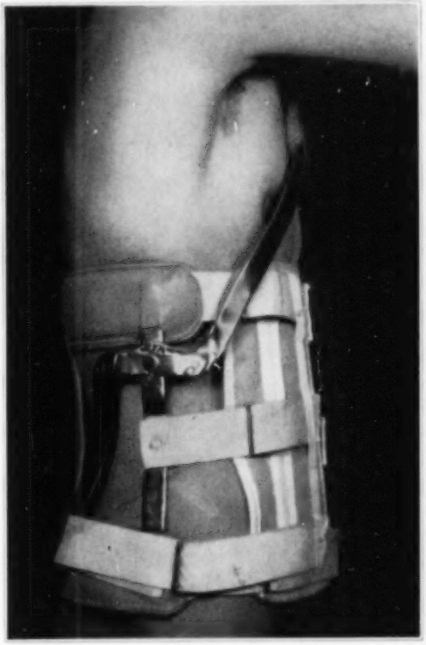

FIG. 2

sternum. The lower free ends contain slots and extend to the level of the posterior part of the pelvic band. Webbing or elastic straps, which are attached firmly to the pelvic band, are drawn through the slots where they are reversed and fastened to the lower part of the abdominal apron or pad.

The U-shaped frame is removable, permitting an easier application of the brace. The pivots are placed at the appropriate level for the individual patient. Figure 2 shows another type of hinge device used.

The U-shaped frame does not interfere with the motions of the upper extremities. Its outlines are curved to follow the shape of the pectoralis muscles on the chest wall. This type of functional brace permits the control of hyperextension of the spine by tension on the straps. It provides good stabilization without undue pressure on the symphysis pubis. It may also be attached to lower-extremity braces when indicated. Patients report that it is quite comfortable to wear.

This brace, as any other mechanical support, should be used with discretion. There can be very little benefit derived from hanging an apparatus on a patient if its possibilities and limitations are not understood. The success and failure of treatment with mechanical supports depends on the manner in which different physiological principles are combined and alternated. Braces may provide the necessary rest and alignment, but they will not provide the muscle strength which is essential in the recovery of the patient from any disease associated with neuromuscular dysfunction. Therefore, this rest must be alternated with judicial use of progressive graduated exercises.

1. VON WERSSOWETZ, ODON F.: Biophysical Basis for the Selection of Functional Back Braces. Arch. Phys. Med., **33**: 676–685, 1952.

"BUCKET-HANDLE" TEAR OF THE MEDIAL MENISCUS IN A FIVE-YEAR-OLD BOY

BY HERBERT VOLK, M.D., AND FREDERICK M. SMITH, M.D., NEW YORK, N. Y.

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Injuries to the medial meniscus are common in vigorous young adults, less common in adolescents, and rarely if ever heard of in young children. The purpose of this paper is to report what we believe to be the youngest patient with a "bucket-handle" tear of the medial meniscus so proved at operation.

CASE REPORT

T. R., Case No. 763489, Presbyterian Hospital, New York City, a normal, well developed boy, aged five years and two months, slipped and fell between two adjacent sections of pipe on December 4, 1949, while playing. The foot was caught in the narrow space, thus immobilizing the leg, and his falling body caused the femur to twist on the articular surface of the tibia. Since he suffered immediate pain, he was admitted to the Emergency Ward one hour after injury.

Physical examination revealed that the right knee was held in 20 to 30 degrees of flexion and that the joint was swollen. Tenderness was noted on palpation over the joint line on its medial aspect.

Postero-anterior and lateral roentgenograms of the knee were negative for evidence of a fracture or loose body. The tentative diagnosis was contusion of the knee-joint region on the right.

Treatment consisted in application of an elastic bandage to the knee; the patient was instructed in exercises for the quadriceps muscles and was allowed to go home. When he was next seen in the Clinic, on December 7, 1949, the right leg was held in 30 degrees of external rotation and the knee could not be extended actively beyond 160 degrees. Pain and tenderness persisted as before. A posterior molded splint was applied and the child was given crutches to relieve him of weight-bearing on the injured side. He was followed at frequent intervals in the Clinic and, although the swelling and pain in his knee gradually diminished, tenderness remained over the medial aspect of the joint. Marked tightness and spasm of the hamstring muscles also persisted, and joint motion remained limited to 160 degrees of extension and 110 degrees of flexion.

The patient was admitted to the Hospital December 26, 1949, twenty-three days after injury. Continuous skin traction with eight pounds of weight was applied to the right leg in an attempt to overcome the flexion deformity of the knee. Two days later the weight was reduced to four pounds. Despite two weeks of traction, initially Russell's and then Buck's extension, together with other supportive therapy, only slight improvement was noted. On January 10, 1950, the child was allowed to go home and was encouraged to continue with active exercises.

On January 16, 1950, a plaster splint was re-applied because of the persistent flexion contracture of the right knee. The plaster was wedged on subsequent visits and straightened so that by the end of one week it was possible to extend the knee to 175 degrees. Because of this improvement, full weight-bearing was again encouraged.

On January 25, 1950, the patient tripped at home, falling again on his right knee. Roentgenograms again were negative for fracture or an intra-articular loose body. The joint was swollen and there was limitation of active motion. Pain was referred to the medial aspect of the joint. Despite intense conservative therapy, consisting in exercise and use of the limb, quadriceps atrophy increased and the flexion contracture of the joint became more pronounced. The patient was re-admitted to the Hospital for exploration of the right knee joint. The possibility that this might have been an injury of the medial meniscus had been considered, but the lesion was thought to be probably some form of synovitis or possibly a chondritis. In any event the condition of the joint was getting worse rather than showing improvement as a result of conservative therapy. Roentgenograms on February 8, 1950, showed a moderate diffuse osteoporosis of the bones about the right knee joint.

Pathological Findings

At operation, on February 10, 1950, it was impossible to extend the knee beyond 175 degrees even under complete anaesthesia. Arthrotomy revealed an almost complete "bucket-handle" tear of the medial meniscus with all but the anterior and posterior attachments displaced into the intercondylar notch (Fig. 1). There was likewise a partial tear of the anterior cruciate ligament. The lateral meniscus was seen; it was palpated and appeared normal. The articular cartilages of the patella, femur, and tibia appeared normal. The synovial membrane in the region of the intercondylar notch was somewhat injected.

Operative Procedure

A ten-centimeter curved skin incision was made on the medial aspect of the knee. Towels were used to isolate the skin margins and the joint was entered in the line of the main incision. Following exploration, the anterior end of the medial meniscus was dissected free, grasped with a Kocher clamp, and then divided with scissors from its posterior attachment. A second incision was made behind the medial collateral ligament and a few remaining tabs of the medial meniscus were likewise removed. Following this, the joint was thoroughly irrigated with saline solution. The wound was closed in layers without drainage, interrupted silk sutures being used throughout.

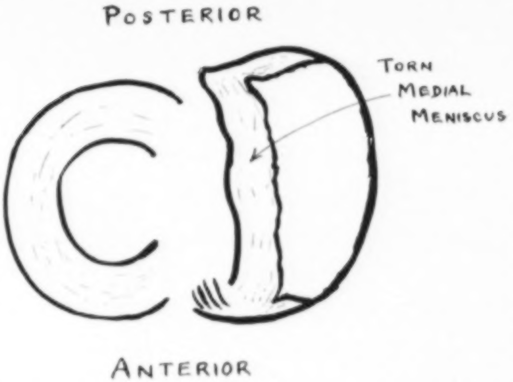

FIG. 1

Sketch showing complete "bucket-handle" tear of the medial meniscus with displacement into the intercondylar notch.

The patient was allowed in a wheelchair the day after operation and was encouraged to perform quadriceps exercises. Full weight-bearing on both legs was started on the eighth day after operation, at which time the active range of motion in the knee which had been operated upon was 65 to 175 degrees. Considerable quadriceps atrophy persisted.

Result

The patient was discharged from the Hospital on the twelfth day after operation, bearing full weight on both legs without pain, and continued under treatment in the Clinic until April 1, 1950. After that time he was followed in the Fracture Follow-up Clinic and was last examined on May 20, 1952, two years and three months after operation. At that time he engaged in all activities without limitation and was very active. His only complaint was slight pain after playing baseball and on kneeling. The scar was well healed and the right knee joint was not swollen or tender. The quadriceps muscles of each side were equal in size and their tone was excellent. There was no anteroposterior or lateral instability in the right knee as compared to the left. The range of motion was 35 to 180 degrees in both knees. He was able to squat (Fig. 2-A) and to get up without difficulty. There was no excess fluid in the right knee joint.

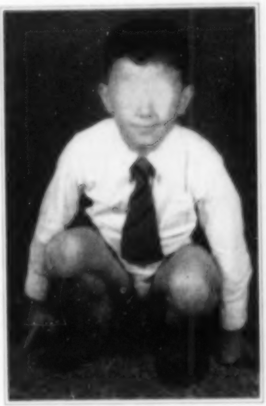

FIG. 2-A

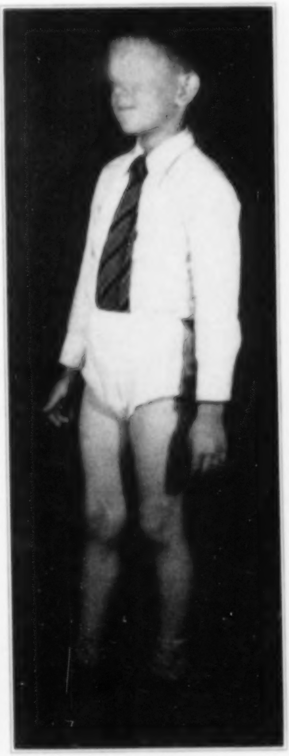

FIG. 2-B

Photographs taken one and one-half years after operation, showing full extension and flexion of both knees and the operative scar.

DISCUSSION

A review of the records of the Fracture Service of the Presbyterian Hospital in New York City over the past twenty-four years and interrogation of many orthopaedic and general surgeons has failed to reveal a case with similar findings in a patient younger than ten or eleven years of age. We believe this is the youngest patient in whom the diagnosis has been proved at operation.

The mechanics by which this injury is incurred is well known and does not warrant repeating.

The authors do not mean to imply that this is a common injury in children and that early surgical exploration should be encouraged. Rather, they wish to report this documented case and to point out that, in children with persistent symptoms and objective findings in an injured knee, the diagnosis of a tear of the medial meniscus should be considered. If no real improvement is noted after an adequate trial of conservative therapy, arthrotomy may be indicated.

THE USE OF COMMON CARPENTERS' TOOLS IN INTRAMEDULLARY NAILING OF FRACTURES OF THE FEMUR

BY B. R. WILTBERGER, M.D., COLUMBUS, OHIO

From the Department of Surgery, Section of Orthopaedic Surgery, College of Medicine, Ohio State University, Columbus

In order to facilitate and make less traumatic the intramedullary nailing of the femur, it has been common practice for the past year to make a pathway of standard size through the medullary canal of the femur before inserting the nail. Stryker recently enumerated the advantages of this step as an integral part of the intramedullary-nailing procedure and outlined the surgical technique to be employed.[1]

Among the tools adopted for this stage of the operation, the electrician's bit, three-eighths of an inch in diameter and twenty-four inches long, used in conjunction with a carpenter's brace (Fig. 1), have proved to be practicable as well as durable instruments. The bit, three-eighths of an inch in diameter, permits a snug fit and prevents rotation of the nail.

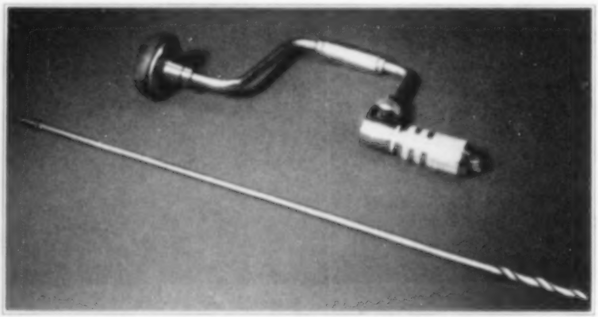

Fig. 1

The carpenter's brace and the electrician's bit.

For the past year, these ordinary carpenters' tools have been used on numerous occasions as a satisfactory surgical instrument in the intramedullary nailing of fractures of the femur with gratifying results and without complications.

CONCLUSION

This tool has many desirable attributes. They are:

1. It will not break.
2. It retains the cutting edge after repeated autoclaving.
3. By the use of this tool, the pathway is cut rather than driven. This is advantageous, for cutting is less shocking and minimizes the possibility of shattering the bone.
4. It can be used for either clover-leaf or diamond-shaped nails.
5. The bit is available in many diameters and, therefore, can be used in other intramedullary-nailing procedures.
6. The brace has a rachet and is adaptable where a full turn can not be taken.
7. It may be purchased at any good hardware store at nominal cost.

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[1] Stryker, H. H.: A Broaching Tool to Facilitate Intramedullary Nailing. J. Bone and Joint Surg., **34-A**: 230-231, Jan. 1952.

THE CARE AND TREATMENT OF CRIPPLED CHILDREN IN THE UNITED STATES *

BY A. R. SHANDS, JR., M.D., WILMINGTON, DELAWARE

From the Alfred I. duPont Institute, Wilmington

It is most fitting on the occasion of this historic gathering to have a report on the program for the care of the crippled child in one of our English-speaking nations, for certainly in the development of our specialty the importance of the child has been stressed for over two centuries. It is also most appropriate that the presentation of the care and treatment of the crippled child of the United States takes place in Great Britain, to which country we in America owe so great a debt of gratitude for what so many of your illustrious and inspiring leaders, such as Hugh Owen Thomas, Sir Robert Jones, and Dame Agnes Hunt, have done in the past in molding our opinions and guiding our programs. My discussion of this subject will be divided into five parts: (1) History; (2) Institutional Care; (3) Instruction; (4) Investigation; and (5) Survey of State Services.

HISTORY

The history of the care of the crippled child in the United States is in reality the history of orthopaedic surgery in our country, but for this discussion the historical portion will include only the presentation of the more significant "firsts".

William Detmold was the first well known physician in America to practice orthopaedic surgery as a specialty. He arrived in New York in 1837 from Hannover, Germany, and it is this year which should be designated as the year of the beginning of an American school of orthopaedic surgery. Detmold, like William J. Little who returned to London also in 1837 from Hannover, studied under Stromeyer and first became known in America for the application of Stromeyer's principles of tenotomy. In 1841, Detmold opened at Bellevue Hospital in New York City the first public clinic for the care of the crippled child.

In the same year, Valentine Mott, one of America's foremost surgeons, returned from an extended trip in Europe, impressed with the orthopaedic institutions and their work in France and Germany, and particularly with the work of M. Jules Guerin in Paris. In 1841, he announced the opening of an "Orthopaedic Institution at Bloomingdale, New York, for the Treatment of Curvatures of the Spine, Club Feet, etc.". This should have been our first hospital for crippled children, but because of the lack of encouragement and, in fact, the discouragement on the part of his medical confreres in New York, who looked with disfavor on specialization and some of whom even considered orthopaedics a form of quackery, this hospital was never opened.

In 1853, Louis Bauer, born in Stettin, Germany, and educated in medicine in Berlin, came to New York from England and settled in Brooklyn. He had studied with both Stromeyer and Little. Because of his political activities in Prussia before he arrived in England in 1849, he had been imprisoned for ten months and then forced to leave his native land. He is spoken of by Sir Arthur Keith as "the real founder of the American School of Orthopaedics" and is referred to by Hugh Owen Thomas as "the best exponent of American orthopaedics". In 1854, Louis Bauer, with Richard Barthelmess, opened an orthopaedic institution in Brooklyn, which was probably America's first orthopaedic hospital. His best known work, Lectures in Orthopaedic Surgery, published first in 1864, with a second edition in 1868, constituted the first American textbook. This book was translated into German in 1870 and later into Italian. It is recorded that partly because of many violent arguments he had with New York's three great men in orthopaedic surgery of that day — namely, Lewis A. Sayre, Henry G. Davis, and Charles Fayette Taylor — concerning the principles of rest, traction, braces, and ambulation, he left Brooklyn in 1869 and went to St. Louis where, in 1878, he became the founder, Professor of Orthopaedic Surgery, and later Dean of the College of Physicians and Surgeons of St. Louis. From the story of his life, it can truthfully be said, as was said of Benjamin Rush, "He was never a passive participant in any cause".

Our first professor of orthopaedic surgery was Lewis A. Sayre of the Bellevue Medical College of New York, who received his appointment in 1861. He is best known for being the first to perform a successful resection of the hip joint in 1854 and to use plaster-of-Paris to support the body in disease and injury. Sir Arthur Keith speaks of Sayre as being "the forerunner of the modern American School of Orthopaedic Surgeons". Sayre was one of the outstanding figures in New York medicine of the day and in 1880 became not only President of the American Medical Association but also the first President of the American Surgical Association.

In December 1862, the first ward for crippled children was opened in Boston at the Samaritan Hospital by Buckminster Brown. He had studied under Stromeyer in 1845 and 1846, and in 1866, according to Osgood, he became probably the first orthopaedic surgeon in the United States to limit his work wholly to the specialty. In this same year of 1866, Charles Fayette Taylor founded the New York Orthopaedic Dispensary, which in 1870 became a hospital. In 1863, James Knight, a great conservative and an apostle of exercise and braces, opened the first permanent hospital for orthopaedic patients in New York City. This was named the Hospital for the Ruptured and Crippled. In this hospital, Knight insisted upon the children being given academic education and religious training; this represents our first formal education of crippled children in an institution. In 1872, the first convalescent home for crippled children, the Children's Seashore House, was opened at Atlantic City by William Bennett. This was for the "marine medication of the crippled child". "The young child was allowed to stay in the ocean only four minutes, for a stay longer than this was thought to be injurious to his health."

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* Read at the Joint Meeting of the Orthopaedic Associations, London, July 2, 1952.

In 1897, through the efforts of Arthur J. Gillette, the first state crippled children's hospital was established in Minneapolis. The emotional appeal of a young crippled woman appearing before the Minnesota State Legislature was the deciding factor in obtaining funds for this project. In 1899, the first public school class for the education of the crippled child was opened in Chicago; this was the forerunner of the many schools and the hundreds of classes for the handicapped child in the United States today.

In 1919, the first national and international lay organization for crippled children was organized; it has now broadened its program to include handicapped adults and is called the National Society for Crippled Children and Adults, Inc. In 1922, in large measure as the result of the efforts of Michael Hoke of Atlanta, the first of a series of fifteen Shriners' Hospitals for Crippled Children in the United States and Canada was opened at Shreveport, Louisiana. The contribution which the Shriners have made over the last thirty years to the care of the crippled child in North America is probably the greatest single contribution any lay organization has ever made to one medical project.

In 1935, the first crippled children's program of the Federal Government was established by the Children's Bureau of the United States Department of Labor with an appropriation of nearly $3,000,000. This has now been increased to over $11,000,000 and is distributed to the states on the basis of need and matching funds. The entrance of the Federal Government into this medical activity was the direct cause for the improvement and, in some instances, the establishment of state crippled children's programs in all of our forty-eight states and the territories.

In 1935, the first hospital devoted entirely to the treatment of a single crippling disease in childhood, namely cerebral palsy, was opened by Winthrop M. Phelps in Baltimore, Maryland. This has been the inspiration and training center for hundreds of workers in this special field from all over the world and has been the direct cause for the establishment of over 500 cerebral-palsy centers in the United States alone.

In 1936, the first foundation devoted wholly to the problems of the crippled child was founded in Jacksonville, Florida. This is the Nemours Foundation, of which the author is the Medical Director. This Foundation operates, in Wilmington, Delaware, a crippled children's hospital and school with laboratory research facilities, the Alfred I. duPont Institute, and supports substantial programs of direct care to the crippled children of the States of Florida and Virginia.

In 1938, the first foundation for a single orthopaedic crippling disease was established,—namely the National Foundation for Infantile Paralysis, Inc. This was started because of the intense interest in the disease of our President, Franklin D. Roosevelt, himself crippled by poliomyelitis; he represents perhaps the greatest example in history of the success of a severely handicapped person. The support for the National Foundation is entirely voluntary; during the campaign of 1952 approximately $40,000,000 was raised throughout the United States. In 1950 the first national lay society for cerebral palsy was organized, the United Cerebral Palsy Association, which is the last of our more significant "firsts".

A comprehensive program for crippled children's care should not only give direct medical aid to the child in the clinic, the hospital, or the convalescent home, but also should provide for both the training of the varied personnel needed in the programs, as well as investigation on the many unsolved problems relating to his care. Academic instruction of this child, followed by vocational training when indicated, is important and may be given in the institution, in the home, or in special schools and classes. For convenient grouping, this program may be considered in terms of the three I's: I for Institutional Care, I for Instruction of the Child and Worker, and I for Investigation. The next three sections will follow this grouping.

INSTITUTIONAL CARE

At the present time there are on the state registers in the United States approximately 700,000 children handicapped by orthopaedic conditions, under the age of twenty-one years, of whom 60 per cent. receive some type of medical care each year.

The last published statistics on facilities for the care of the crippled child in 1951 (Table I) showed that there were eighty-two orthopaedic children's hospitals with 6,708 beds and ninety-one convalescent homes with 6,400 beds which admit crippled children. This represents approximately 13,000 beds in special institutions which either are designated or can be used for the crippled child. There are, in addition, hundreds of beds which can be used for the hospitalization of the crippled child in general hospitals. The average daily occupancy of these beds in the special institutions is approximately 75 per cent. There are now very few

TABLE I

Facilities for Special Institutional Care of the Crippled Child in 1951

	No.	No. of Beds
Children's orthopaedic hospitals	82	6,708
Children's orthopaedic convalescent homes	91	6,400
Total	173	13,108
Average bed occupancy per day		75 per cent.

states and territories of the United States which do not have adequate hospitalization facilities for their crippled children.

During 1950 there were 247,000 crippled children who received services in the state programs (Table II). Of this number 43,600 children were hospitalized for a total of over 1,400,000 days at an average stay of 32.7 days per child and 5,800 children were cared for in convalescent homes for a total of 560,000 days at an average stay of 95.2 days. Thus 20 per cent. of the total active case load on the state registers for this year represented patients in institutions. There are no statistics available on the number of children cared for in institutions whose expenses are paid from sources other than state or Federal funds. As an example, in the fifteen Shriners' Hospitals which have not published their statistics, it is estimated that over 7,000 children are cared for each year and over 250,000 hospital days of care are being given. It is further estimated that the total figures for the hospitalization and the convalescent home care of crippled children should be from 25 to 35 per cent. greater than those given for the state programs alone.

During the past fifteen years, the average hospital stay for the children in the state programs has decreased from 53 days to 32.7 days, while the average convalescent-home stay has varied from 86 to 108 days, but has not decreased. There has been a steady increase in the number of children receiving services, this increase being at a rate of 15 per cent. a year since 1945. Each state program has a system of out-patient clinics for case finding, diagnosis, and follow-up examinations. These are usually located so that the patients will have to travel the minimum distance. Many of the clinics, however, are operated in conjunction with the hospitals. Approximately 85 per cent. of the children receiving state services visit the clinics each year for an average of two visits per child.

The diagnoses of the crippled children in the last thirty-five years have definitely changed (Tables III and IV). The tuberculous-joint conditions which during the nineteenth century constituted from one third to one half of the cases in crippled children's clinics and institutions in 1950 constituted only 2.1 per cent. of the total number of orthopaedic patients treated in the state programs, the highest incidence in any one state being 8 per cent. Pyogenic osteomyelitis, which was at one time such a common cause of crippling in childhood, now constitutes only 2.8 per cent., because of the early use of the antibiotics. The number of cases of infantile paralysis is not decreasing. During 1950 over 31,000 children with poliomyelitis were treated in the state programs, or 22.2 per cent. of the total. This does not represent the total number in the country, as in that year approximately 28,000 new patients under twenty-one years were reported by the National Foundation for Infantile Paralysis. The number of congenital malformations in the crippled children's clinics is increasing. In 1950, these constituted 29.7 per cent. of the total, the largest percentage being club-foot (10.4 per cent.). In certain sections, such as the Southeast, the percentage is greater than in the other sections of the country. Cerebral palsy is the next largest group and constitutes 13.8 per cent. of the total number of cases. However, it is estimated that there are approximately 175,000 cases of cerebral palsy in the United States, or 25 per cent. of the total estimated number of crippled children. Rickets, which many years ago was such a common cause of deformity in the growing child, in 1950 was only responsible for 1.4 per cent. of the total number of reported cases. The chart prepared from the 1950 statistics of the Children's Bureau (Table IV) gives the incidence of the fifteen most common conditions or groupings of conditions in

TABLE II

Institutional Care of Children in State Programs for 1959

Total number of children receiving clinic and institutional services	247,000
Total number of children in hospitals	43,600 (17.6 per cent.)
Total number of children in convalescent homes	5,800 (2.3 per cent.)
Total number of hospital days	1,400,000
Total number of days spent in convalescent homes	560,000
Average stay per child in hospital	32.7 days
Average stay per child in convalescent home	95.2 days

TABLE III

ORTHOPAEDIC CONDITIONS
(STATISTICS ON 142,177 HANDICAPPED CHILDREN IN STATE PROGRAMS IN 1950)

	Per cent.
1. Neuromuscular disorders	36.0
2. Congenital malformations	29.7
3. Developmental disorders	27.7
4. Infections of bones and joints	6.6

142,177 orthopaedically handicapped children, which is 66 per cent. of 216,623, the total number of children receiving services under the state crippled children's program for that year.

There are no exact figures available on the cost of crippled children's care; however, it is estimated that in 1950 approximately $30,000,000 was spent by the states and territories in their crippled children's programs. If 25 to 35 per cent. more care is being given through private sources, the total would then be between $37,500,000 and $40,500,000. Of the amount spent for state care approximately 25 per cent., or one in every four dollars, comes from Federal funds. The costs of care have steadily risen and have increased so sharply in the last several years that two years ago many of the states were forced to curtail their programs because of lack of funds. Since 1940, the average cost per patient per day in most hospitals has increased from 200 to 250 per cent. During 1950, the average cost of institutionalizing a crippled child in a state-designated institution was approximately $327.00 in a hospital and $666.00 in a convalescent home.

INSTRUCTION OF THE CHILD

In thirty-nine of the forty-eight states there are programs for the special education of the crippled child, or the exceptional child as he is most often spoken of (Table V). The number of special education services in the city schools has increased from 729 cities with such services in 1940 to 1,459 in 1948, a growth of 100 per cent. The total number of children in 1948 known to be receiving special education was over 440,000. It is estimated, however, that not more than 15 to 20 per cent. of the approximately 6,500,000 children needing special education are receiving such. In all programs for the education of the exceptional child are included non-orthopaedic conditions, such as visual and hearing losses, epilepsy, rheumatic fever, speech defects, and cardiac conditions. The orthopaedically handicapped children constitute approximately 8 per cent. of the total number in need of special education. This special education is being given in the institutions, in special schools, in special classes held in schools for normal children, and in the home for those unable to go to school. In 1948, of over 30,000 orthopaedically handicapped children, 47.5 per cent. were in schools and special classes, 27.7 per cent. in hospitals, and 24.6 per cent. in homes. Two out of three handicapped children can attend the regular classes with normal children.

The weakness in the program for the education of the child handicapped by an orthopaedic condition is in the general hospitals, where there are seldom enough children at one time to justify the full-time services

TABLE IV

DIAGNOSIS
(142,177 CASES)

	Number	Per cent.
1. Poliomyelitis	31,851	22.4
2. Cerebral palsy	19,574	13.8
3. Other diseases of bones and joints, including the osteochondritides	18,980	13.3
4. Club-foot, congenital	14,803	10.4
5. Flat-foot, acquired	13,030	9.1
6. Other congenital malformations	12,361	8.7
7. Cleft palate and harelip	7,949	5.6
8. Scoliosis, idiopathic	5,358	3.8
9. Osteomyelitis, pyogenic	3,923	2.8
10. Tuberculosis of bones and joints	3,019	2.1
11. Flat-foot, congenital	2,701	1.9
12. Hip dislocation, congenital	2,682	1.9
13. Arthritis, rheumatoid	2,456	1.7
14. Rickets, active and old	2,043	1.4
15. Spina bifida with meningocele	1,717	1.2

TABLE V

INSTRUCTION OF THE CRIPPLED CHILD

Number of states with special programs for education of exceptional children (1951)	39
Number of cities with special education programs (1948) (100 per cent. increase in 8 years)	1,459
Total number of children in need of special education (estimate)	6,500,000
Percentage of total receiving special education (estimate)	15
Percentage of total number of children receiving special education who have orthopaedic conditions	8
Location of special education in 1948 for 30,000 children with orthopaedic conditions:	
a. In special schools	47.5 per cent.
b. In special classes	27.7 per cent.
c. Home instruction	24.6 per cent.

of a teacher. It is very heartening to see the increase in the number of facilities for the education of the child with cerebral palsy which have been developed over the past several years.

In one survey of 10,000 crippled children attending school, 80 per cent. were in the first to the eighth grades, 7.4 per cent. in grades higher than the eighth, and 4.4 per cent. in nursery school.

Each state has its vocational rehabilitation services, usually operated as a division of the state department of education, working very closely with the orthopaedic clinics and institutions. In the United States training in state vocational rehabilitation programs may legally begin at the age of sixteen. In the year 1951, 14,118 orthopaedically handicapped children between sixteen and twenty-one years of age were rehabilitated by the state services. It is interesting to note that 51.4 per cent. of these rehabilitants were crippled because of disease, 30 per cent. because of congenital malformations, and 5.1 per cent. because of amputations or congenital absence of the extremities. Of nearly 184,000 rehabilitants of all ages in the last three years, 20 per cent. were under twenty-one years of age (Table VI). The state services not only train but also furnish vocational guidance, find employment for the rehabilitants, and follow them until they have made a satisfactory vocational adjustment. In the United States, there are practically no programs of vocational education which are operated as a part of a crippled children's institution as are to be found in Great Britain.

INSTRUCTION OF THE WORKER

The training of the worker, particularly of the doctor, the nurse, the therapist, and the teacher, in crippled children's activities is another very important part of the program. The lack of adequate personnel has frequently proved to be the bottleneck of many programs.

The three-year training course of the orthopaedic surgeon in the United States includes one year of children's orthopaedics. In 1951 there were 261 hospitals approved for orthopaedic training, offering a total of 800 residencies (Table VII). Of this number approximately 220 orthopaedic residencies were in work with crippled children in 117 approved hospitals. Each institution approved for work with crippled children has not less than twenty active beds for crippled children. If an orthopaedic surgeon is to participate in a state program for crippled children, he must now be certified by The American Board of Orthopaedic Surgery or he must have completed his training for Board certification.

There are eight schools of nursing offering orthopaedic training with a capacity for 152 students. In addition, many short postgraduate courses are being given for the orthopaedic nurse. There are definitely not enough properly trained nurses in the hospitals and state programs.

In 1951, there were thirty-one schools for training physical therapists, graduating 498 students, and twenty-four schools for occupational therapists, graduating 418 students. The number of graduates of these

TABLE VI

STATE SERVICES FOR VOCATIONAL REHABILITATION (1949–1951)

	No. of Patients	Per cent.
Total number of patients of all ages:	183,810	
Total number under 21 years:	37,504	20.4
Cause of disability in rehabilitants under 21 years		
a. Disease		51.4
b. Congenital malformations		30.0
c. Amputation or congenital absence of extremity		5.1

TABLE VII

ORTHOPAEDIC RESIDENT TRAINING PROGRAM IN 1951

Total number of approved hospitals	261
Total number of residencies	800
Number of hospitals approved for crippled children's training (45 per cent. of total)	117
Number of crippled children's residencies (27.5 per cent. of total)	220

schools does not meet the demand for work in these special fields. The greatest shortage now in the state programs is of physical therapists and next of trained social workers. There is a scarcity of the number applying to be trained in speech and recreational therapy; such therapists are extensively used in all of our programs.

There is definitely a shortage of trained brace makers. This training is at present almost entirely under an apprenticeship system. A recent advancement in this field is the establishment of the American Board for Certification of brace-makers and limb-makers.

There are now 175 universities giving special courses to teachers for work with the handicapped child. It has been recognized that the number of teachers with special training will never be sufficient to meet the demand, so that in nearly all states special education courses are being given for the classroom teacher.

INVESTIGATION

Investigations on problems of the causes of crippling in childhood undoubtedly constitute the most important research in our specialty. Some of our university centers have excellent programs of biochemical, physiological, pathological, and anatomical research related to the crippled child, but there are not enough of these programs. Some of the more important basic problems now being investigated in the orthopaedic clinics in the United States are bone growth, epiphyseal stimulation, repair of bone, protein content of bone, biomechanics of gait, scoliosis, congenital deformities, muscle physiology, and poliomyelitis. Research in connection with metals and other materials for braces is another recent development.

Nearly every clinic has some type of program of clinical investigation with follow-up studies on its cases. In many clinics there are animal investigations related to surgical procedures. In the last survey made of orthopaedic research in 1940, there were 368 laboratory and clinical projects in 190 institutions. Of these 11 per cent. were wholly laboratory; 54 per cent. were clinical and laboratory; and 35 per cent. were wholly clinical. Another survey is now being conducted by the National Research Council. It is the author's opinion that since 1940 the volume of research has more than doubled. The orthopaedic surgeon of the past was interested more often in clinical matters than in research, probably because of his early training. In recent years, there has been more emphasis placed upon basic science and research in the teaching centers, so that the orthopaedic surgeon now finishing his training nearly always has an interest in some research problems. One of the outstanding research orthopaedic clinics in our country today is at the University of California where teaching, research, and clinical practice are coordinated into a pattern which it would be well for every large clinic to follow.

SURVEY OF STATE SERVICES

During 1951, a survey was made of the crippled children's services in the forty-eight states, the District of Columbia, Hawaii, Alaska, Puerto Rico, and the Virgin Islands, by the Joint Committee on the Public Care of the Crippled Child of which Dr. A. Bruce Gill is Chairman and the author is Secretary. This survey was made primarily to secure the opinions of the orthopaedic surgeons who were actively participating in the state programs.

As a result of this survey, not only were many needs pointed out, but also many weaknesses in the programs became apparent. Forty needs were listed from fifty-three sources (Table VIII). As might be predicted, the most frequently mentioned need (fifteen times) was for more funds. The second greatest need (twelve times) was the lack of an adequate number of social workers and the need for better social-service investigation. In addition to inadequate social work, the shortage of personnel was almost everywhere apparent, but shortage of physical therapists was next in frequency, followed by shortage of nurses, occupational therapists, and speech therapists. The need for better coordination in the state programs and interagency liaison was mentioned eight times. The doctors in seven states were cognizant of the lack of adequate educational facilities for the children. Five states needed better facilities for the care of the child with cerebral palsy. In four states the hospital facilities and number of crippled children's beds were not adequate and in four states attention was called to the fact that the follow-up of hospital patients in the clinics was not satisfactory. Proper parent education was mentioned as a need three times, but probably is a need in all states. In two states the programs were definitely not well administered and in two other states it was felt that the vocational rehabilitation services were not active enough. In two states the need for convalescent facilities was mentioned, but, as a general rule in the country as a whole, the policy is to send the children from the hospital back to their own homes as soon as possible after surgery and normal postoperative care.

TABLE VIII

MOST IMPORTANT OF FORTY NEEDS REVEALED IN 1951 STATE SURVEY OF ORTHOPAEDIC SURGEONS
(IN ORDER OF FREQUENCY MENTIONED)

1. Additional funds
2. Better social-service investigation and follow-up
3. Additional personnel
    a. Social workers
    b. Physical therapists
    c. Nurses
    d. Occupational therapists
4. Better coordination between agencies
5. Better educational facilities
6. More facilities for care of the child with cerebral palsy
7. Evaluation surveys of professional care
8. Programs of parent education
9. Facilities for domiciliary care of the hopelessly crippled child

In many states, in recent years, convalescent homes have been closed because of the small number of children needing this type of service. One need which was only mentioned once, although it is believed to be a real need in every state, is facilities for the domiciliary care of the child hopelessly crippled with cerebral palsy, progressive muscular dystrophy, infantile paralysis, and similar conditions.

It was the opinion of the Joint Committee that the best operated state programs were those which were administered by a special crippled children's commission or medical agency. The programs were being administered by a health department in thirty-one instances, a welfare department in ten instances, a crippled children's commission in four, an education department in three, and a health and welfare department in one. It was found that where a crippled children's program did not have an independent status, monies often were being appropriated by legislatures when the legislators did not know how much was actually needed for the care of the crippled child. This was believed to be an unfortunate situation and in many instances the Committee was of the opinion that the crippled children's programs were suffering.

It was found often that, because of a state agency policy of having the crippled children cared for by orthopaedic surgeons as close to the homes of the patients as possible, some of the older established institutions were not obtaining sufficient patient material for teaching and investigation. Moreover, this policy of decentralization in many instances definitely was not resulting in the best of medical care for the children.

It was appreciated by the Committee that in many states the medical care of the crippled child was not what it should be. The Committee strongly endorsed state evaluation surveys of professional care by competent and older orthopaedic surgeons from other states.

There was no doubt that in many states there was a duplication of services in which different agencies were actually competing for the care of the crippled child. The Committee recommended that a state coordinating committee be established in every state, made up of representatives of all the crippled children's private and public agencies.

Many of the programs lacked the leadership of the orthopaedic surgeons and often political influence had crept into the programs. The Committee very strongly recommended that the orthopaedic surgeons should always be active in the administration of their state programs and that, when political influences were affecting the programs adversely, they should see that steps are taken through state, county, and city medical societies to remove these political influences.

As a result of this survey, recommendations for the improvement of the crippled children's services were made by the Joint Committee to the Executive Committees of The American Orthopaedic Association and The American Academy of Orthopaedic Surgeons for their approval. These recommendations then will be presented to the Children's Bureau of the Federal Security Agency for their consideration and hoped-for action.

CONCLUSION

The author hopes that from this short discussion of our past and present activities the reader has been able to obtain some idea of the problems of the care and treatment of the crippled children in the United States. We are all working for the betterment of our programs, whether it is in Great Britain, America, or other parts of the world. As a result of our efforts, it can be hoped that there will everywhere be a continued rehabilitation of the greatest possible number of orthopaedically handicapped children. None of us will ever live to see the day of the perfect program in any state or nation; we can only hope that it can always be said that the orthopaedic surgeons of today are meeting their responsibility for the restoration of the crippled child to a normal life, or as nearly normal a life as possible.

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THE NATIONAL HEALTH SERVICE AS WE FOUND IT

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During April and May 1951, my wife and I wandered through the British Isles where our ancestral roots tapped deep. Our younger radices were all in the New World. We had learned why our ancestors had fled to Ireland and what drove them on to America, and we rejoiced in their fateful decision. Yet we found much of profit among our friends across two seas. The clear story of their valiant daily struggle has been frequently distorted in transmission and parts have been jammed by vested interests. Not the least of these garbled stories concerns the National Health Service. In 1952 we had a further brief opportunity to learn of change.

We had assumed, from information current in the United States, that the British Health Service was an abomination utterly abhorrent to the British doctors and condemned by many a loyal Briton. From the moment we encountered a physician from Belfast on a train in Switzerland, we became conscious that all was not as it had been represented to us. For two months wherever time, circumstances, and persons permitted, we put the question, "What about the National Health Service?"

In not a single instance did we get an outright condemnation of the plan, although the doctors expressed a deep dislike of its regimentation and were unanimous in their condemnation of the manner of its introduction. The plan was executed with an arbitrary setting of fees and a promise to adjust the doctor's pay. This promise the Labor Government never kept. Not until 1952 was such an adjustment made in the Danckwerts award[1, 2, 3] which recommended to Parliament an increase in the pay of general practitioners of about 25 per cent. retroactive to 1948. Concerning the tales of which we had heard, little was substantiated; the sweeping condemnation of the system which we had expected we did not find.

We would state at once that we were not convinced that the system should be transplanted across the Atlantic. We believe that many of the present arguments of proponents and opponents are fallacious and should be examined objectively.

Hence it is our purpose here to state briefly what is meant by the National Health Service and to present and analyze the statements favorable and unfavorable to it, as we heard them. At the same time we shall point out the American counterparts of British conditions, so that each may judge for himself.

I

The act of Parliament establishing the National Health Service, which became operative July 5, 1948, was the climax of exactly a century of public-health regulation. During that period legislation had been enacted covering lunacy, school health, industrial welfare, the blind, the deaf-mutes, the cripples, maternal and infant welfare, *et cetera*. At this centennial, Parliament took under its control for the first time almost all the voluntary (endowed) and municipal hospitals in the British Isles, and brought under bureaucratic control most of the physicians and surgeons of the Kingdom, regulating their income and their places of practice.

How does the health plan work? Mrs. Smith had been Dr. Adams' patient for thirty years. On July 5, 1948, she loyally signed up to remain his patient for life. For his services to her he will receive from the Government an annual capitation fee of about $3.00. He knows her foibles, the children she has had, her family, and whether he may joke with her or whether he must remain as Henry VIII prescribed,

> "Profound, sad, and discrete, groundly learned and deeply studied in physic." (Statutes of Henry VIII, 1511.)

She has the doctor of her choice unless she was so slow in signing up that 4,000 signed up before her, in which event she had to take a doctor she knew less well. Her physician cares for her little ills, but, if she becomes very ill, a salaried consultant is called in, or she is sent to the hospital where several strange specialists may see her. A course of action is determined and she receives the best care the Kingdom offers. When the consultation or hospital stay ends, she reverts to the care of her own doctor.

II

Let us hear some of the specific complaints of laymen. An elderly lady of the middle class in Cambridge did not like the Service because of the long delays in getting hospital admission; with indignation London papers reported that a badly burned child was carried to three hospitals before being admitted an hour after her injury.

In Michigan, after our return from Europe, my wife fell and broke her back. She was carried six miles to one hospital and then eighteen miles to another because the first hospital was filled. It can happen here as well as there.

In Britain acutely ill patients such as the one described above are admitted promptly to a government hospital, although one may have to hunt for a hospital which has an empty bed. This is simplified in London, I understand, where there is a single clearing house for all hospital beds. Chronic conditions, such as bunions, may have to wait eighteen months or more, if they are to be treated under the Health Service. If a chronic condition becomes acute, admission is expedited.

If a Briton desires immediate hospitalization for his thirty-year-old bunions and is willing to employ a surgeon privately, he can be cared for in an unnationalized nursing home, just as he would have been prior to the National Health Service. Slightly over 3 per cent. of Britons used private pay beds in national hospitals in 1949–50.[6] How many use nursing homes is unknown. The British estimate that 5 per cent. do.[6] However it was reported in Bath that a person with an acute condition who wanted nursing-home care was sent by the surgeon to a nationalized hospital because of the extra effort involved in going to the nursing home to see a single patient.

(Other delays in the performance of the Health Service are officially recognized—for example, ordinary glasses are delivered in about four months after their prescription, while the delivery of bifocals and other complex prescriptions is delayed eight to nine months, occasionally more. The demand for glasses was so great that Britain had to import glasses during the period of 1948 to 1950 to help overcome the delay.)

How does this hospital shortage arise? The newly nationalized hospitals which hitherto had cared largely for the indigent, were, after 1948, charged with the additional burden of caring for many patients who were formerly treated in nursing homes, as well as with the care of those hitherto too poor to buy and too proud to beg. This multiplication of load has led to a 90 per cent. occupancy of British hospitals. About 70 per cent. occupancy is considered ideal for hospital efficiency, for such a ratio reserves enough beds for sub-atomic emergencies.

A direct comparison of British and American conditions will be of interest:

	Great Britain	*United States*
Persons per general practitioner	2430	880
Persons per qualified specialist	3140	4545
Persons per available general hospital bed	248	374
Persons per hospitalized patient per year, ratio of	16:1	12:1
Average hospital stay	19.5 days	7.9 days in a private hospital 11–15 days in a city or county hospital 26 days in a Federal hospital

From this it appears that Great Britain has proportionately about one third as many general practitioners as the United States and about one-half more specialists and hospital beds, that the British are hospitalized more than twice as long as most Americans, and that a third more Americans are hospitalized than Britons. It also would seem that the length of hospital stay increases rapidly as the size of the controlling body of the hospital increases. It would appear that a Federal system of hospital care here would be more than three times as costly as present methods if Great Britain is any index.

Two contributory factors may prolong the Britisher's hospital stay: the lack of heat in postwar homes and the lack of facilities within the home to permit adequate care of the patient, either with or without help.

These figures do not mean that Americans are in dire need of more hospital beds, for their average occupancy is only about 73 per cent.—very close to the supposedly ideal rate. Neither do they mean that Americans are more unhealthy. The United States has a lower death rate than Britain has, 10.1 against 12.1 (1947); and a lower infant-mortality rate, 34.5 against 40.8 (1946). The figures probably mean that we hospitalize for lesser causes. A study of the figures suggests that British hospital congestion could be materially reduced by shortening hospital stays.

A number of British doctors said that many hospital beds (10.4 per cent.)[6] are at present closed because of a lack of nurses. There is a nurse for slightly more than two hospitalized patients in Britain. In America's general hospitals (non-governmental and governmental below state level) there is a general-duty nurse for slightly less than every two patients. American hospitals, too, have difficulty filling their nursing complement. Why should both countries have nursing shortages? There are three general causes: economic, social, and matrimonial.

We shall consider only general-duty nurses:

Weekly Wages	*British Nurses*	*United States Nurses*
Before World War II	\$4.00 to 6.00 and found	\$18.00 with found
After World War II	\$11.00 to 17.00 without found	\$55.00 to 60.00 without found
General employment average	\$17.00 to 20.00	\$60.00 to 65.00

It is clear that a group of highly trained professional women receive no more salary than does an average bus driver. There is no remuneration for the time used and expenses incurred in training. To this are added certain social disadvantages. During the past few years hospital nursing hours have been shortened from sixty to seventy-two hours a week to forty-eight hours in Britain and to forty or forty-four or forty-eight hours a week in the United States. Working hours are split and the shifts are variable, so that a nurse's social life is nearly non-existent. The result is a trend toward office, public-health, and industrial nursing, and even toward unrelated occupations in which hours are regular, evenings free, and wages at least no worse. Again, many nurses marry before they serve the public for as long a time as they had spent in training. This is an educational waste which must be recognized and accepted.

One intelligent woman complained that, if she and her companion were ill at the same time, the doctor could call on only one because it would confuse the records. This we found to be an error: The law penalizes a doctor who refuses to see the second patient.

The most serious lay complaint came from a prominent clergyman. He felt that there has been a breaking down of the doctor-patient relationship in that it has tended to become "anonymous and impersonal, both general practitioners and patients losing thereby. Under the old system the general practitioners had more responsibility, being able to follow a case through completely. Under the present system they are no longer allowed to treat cases which formerly they would have treated themselves, but are now bound by regulation to send to the hospital. The patient loses the feeling that he is in the hands of someone who has known him for years." To appreciate this we must detour briefly through an interesting but little known field of history.

At the close of the Dark Ages the clergy, who alone had a miniscule of education, cared for the sick. Later medical training was assumed by the universities. University graduates, bound by the pre-Christian Hippocratic oath, were forbidden to cut. However, the need for cutting was not abolished by the oath; therefore, a patient requiring surgery was referred to an uneducated, oathless, but skilled barber. Barbers who became especially deft and skilled with the knife were known as *chirurgeons* (hand-workers), a word later transformed to surgeons. The physicians treated the chirurgeons with high disdain; the chirurgeons had corresponding scorn for the humble shavers.

Henry VIII formed the Royal College of Physicians as a licensing body for physicians, and grouped the surgeons and barbers into a common company, much to the disgust of the former. Not until two centuries later did George II separate them, establishing the Royal College of Surgeons as a licensing body for surgeons. Each College gave its own examinations and, of those passing, a physician was known as Doctor, a surgeon, as Mister.

Administering of the Hippocratic oath was abolished during the last century. Since 1875 any physician may wield the knife, for the examinations admitting to the Medical Register are given by the Conjoint Board of the Royal Colleges of Physicians and Surgeons.

Subsequent to this examination for general practice each Royal College gives extremely stiff examinations and grants higher degrees, indicating more advanced qualifications. It was easy, therefore, for the National Health Service to classify general practitioners as distinct from specialists. Salaried specialists staff the hospitals. Each general practitioner was, in 1948, permitted to enroll a panel of not over 4,000 persons for whose care the Government paid him an annual capitation fee. This number was recently reduced to 3,500. Many have much smaller panels, for there are only 2,430 persons per general practitioner in the whole of Great Britain.

Not until 1877 did anyone in America inquire as to a person's fitness to practice medicine. Illinois led the way. State licensure is now universal and broad, permitting any holder of a medical license, irrespective of his training, to do anything except commit murder, produce abortion, or peddle narcotics. Until twenty years ago specialists were self-designated. Now the profession itself is establishing standards for specialist training, and qualified men are certified by their peers. The self-designated specialist, however, still operates legally.

Medical licensure in England remains a Royal Prerogative. In America it is a right constitutionally reserved to the several states, as is licensure of druggists, dentists, and opticians, and the regulation of hospitals. Britain, therefore, could, and legally did, set up its National Health Service. Our Federal Government could do this only after altering the last article of our cherished Bill of Rights (Tenth Amendment).

The fourth complaint from a layman came from my barber in Liverpool whom I questioned concerning the National Health Service a few days after Aneurin Bevan had resigned.

"We'll have to have a change in government! They promised glasses and false teeth and they have collected taxes for them; and now they tell us *we* must pay half. We'll have to have a change of government!"

On the face of it the barber's wrath seemed justified, but what are the facts? The National Health Service agreed to furnish without charge to the patient glasses and dentures and to pay the dentists and opticians according to services rendered. The unknown quantities in the cost equation were chiefly the number of persons who would ask for the service and the carelessness of the recipients.

These two factors exceeded the wildest estimates. The dental service in the second year exceeded budget estimates by 50 per cent.; ophthalmic services surpassed budget estimates by 83 per cent.—the nation's economy teetered. Dentists and opticians prospered. An attempt was made in May 1949 to balance dental estimates and costs by reducing dental fees by 20 per cent. and by reducing by 50 per cent. gross earnings of over $13,440. In 1950, a further reduction of 10 per cent. was ordered.[8]

The dental situation was illuminated by a conversation with an Oxford student:

"About the only difference I have noticed, aside from not having to pay anything now, is that previously when I went to the dentist I had to sit and chat a half an hour or so. Now he has no time to chat. I like it better."

The 1951 regulation requiring the patient to pay half of these charges will have these effects: It will deter persons from asking for most unnecessary services and perhaps some necessary ones; it will promote carefulness; it will probably decrease the income of dentists and opticians and increase their overhead through collection costs; taxes will be reduced and the national budget will be eased.

Someone will ask, "How is it that the British have such an extraordinary need of teeth and glasses?"

That story is centuries old. The Black Plague of 1348 broke the back of feudalism, releasing the laborer from agricultural serfdom. Scarce laborers sold their services dearly. For the next four centuries the landed gentry struggled to keep farm wages low. The industrial revolution of the last two centuries did little to improve wages. In 1938 the lowest paid workers in Britain (in laundries) received $5.98 per week; the highest (in the steel industry) got $19.18 weekly. The median weekly wage for seventy-two occupations was about $10.00.[7] This provided a pitiful margin for the British laborer to apply to his teeth. Teeth were pulled, not filled; as eyesight failed, people could still grope around. Britons therefore went without teeth and without glasses. Even now, in England, two teeth are pulled to every one filled, and only one vacancy in four receives a denture.[6]

One of the most enlightening discussions developed in a chance acquaintance with two Yorkshire teachers, one a Laborite, the other a Conservative. The latter was principal of a school.

"Last week," said the principal, "a girl was hurt at my school. I called the National Health Service and within five minutes a doctor and an ambulance were there. Under the old system I would have had to call one of the child's parents to guarantee the physician's and ambulance fees. Then I would have had to secure the doctor and ambulance, which might have consumed the better part of the morning before the child could have been cared for." Now the financial responsibility is no longer a cause for delay.

The general practitioners I talked to felt that the patients were getting better care under the National Health Service than formerly, and to this one critic agrees: "in the sense of more adequate specialist attention, but impersonal technical competence may not entirely compensate for the diminished sense of personal interest."

The loss of "fee for service" as well as service regulations have apparently made general practitioners refer patients at an earlier stage of illness. Salaried specialists, we were told, are less selfish and refer patients to fellow specialists interested in a particular field, even though they work in a distant city. Transportation is supplied by the Government.

III

Let us now look at the Service from the professional viewpoint, considering first the complaints frequently heard in America.

All of us have heard of the endless forms British doctors have to fill out. When we raised this question, doctors were almost insulted and showed us their forms which are not one-fourth as large nor are they so complicated as any insurance form in the United States. The giving of benefits in sickness and old age makes necessary the filling out of forms. This is characteristic of any welfare state, rather than of the National Health Service. The additional insurance forms required of American doctors during the past decade have also become a burden.

We had heard of the great abuses of the Service. These were mentioned to us by both lay and professional people and took one of four forms:

1. Demands for unnecessary service. Bandages, adhesive, and the like can be purchased on the open market at small cost; yet people sit in a doctor's office for a considerable time to ask for a prescription for such drugs or surgical supplies. The physician usually tells them to buy bandages and adhesive directly from a chemist's shop. The drug prescriptions more than trebled under National Health Service and their costs exceeded estimates by 67 per cent., but the number of patients at least doubled at the same time.[2]
2. Failure to use the glasses and teeth supplied by the Service.
3. Excessive consultation with specialists. General practitioners are using the specialist-consultants to confirm the statement that there is nothing wrong with a child. While this retains the patient on the panel of the general practitioner, it throws a heavy burden on the consultant. I was in one children's clinic for about three hours and there were about six patients of this type to be seen by the consultant in that time. I would classify this as good use, not abuse.
4. Demand for totally unnecessary services. An orthopaedic surgeon in Edinburgh told of women asking for custom-built corsets or shoes. Such a pair of shoes costs the Government 12 pounds. He advises the patient to buy her own shoes and then he has them modified at a cost of 2 pounds, a saving to the Government of 10 pounds ($28.00).

Under the revised law (1952) a nominal charge is now made for drugs and supplies dispensed. By this means the Service hopes to discourage unnecessary demands.

We had heard that the medical profession had taken a great financial loss under the plan. Every practitioner we talked to, however, said he is as well off as before. That there be no quibbling, let us examine the financial status of physicians in Great Britain and compare it with the status of physicians in the United States.

The median net income of British general practitioners under the National Health Service, according to the British Medical Association[3], was, before the Danckwerts award, about $3,600; 80 per cent. earn less than $5,600; none earn over $11,200. In the United States, according to the Department of Commerce report for 1949, the median net income of general practitioners was $7,438. On the surface it would appear that the American is doing twice as well as his British confrere. However, can a couple get a large twin bedroom in a first-class hotel in New York with bath and breakfast for $7.00 a day? Can an American get the best seats in the best legitimate theaters in any city in the United States for $1.40 to $1.75? Can one ride the New York bus or subway lines for a mile or two for $.02 to $.03, or get a *table d'hôte* dinner at first-class hotels in New York for $1.40 to $1.75? Can an American doctor buy a dozen eggs for $.49? Yet these are the prices we paid in London. Milk in 1952 was selling in London for $.07 a pint, strawberry jam for $.22 a jar, a large can of baked beans or vegetable soup for $.15. The British and American general practitioners in their own home settings are about on a par financially; but when the British practitioner tries to buy his way around America, then he suffers.

Comparison of the income of specialists is more difficult. British specialists are legally divisible into four basic salary grades; 90 per cent. work only part time for government and maintain private consulting rooms. In England, as in Denmark where governmental medicine is operative, people still go privately to the specialist for an examination at a good fee and then have the prescribed treatment carried out at governmental expense. All of the specialists with whom I talked assured me that they are now doing as well financially as before the National Health Service was instituted.

We can more profitably compare the income of the full-time National Health Service specialist with that of the American specialist.

Great Britain			United States	
Grade	Proportion (*Per cent.*)	Salary (*Dollars*)	Independent (*Dollars*)	Salaried (*Dollars*)
1	4	14,700		
2	10	11,900		
3	20	9,100		
4	66	4,900 to 7,700		
Median		6,650	12,599	8,824

It would appear, therefore, that the buying power of the independent American specialist is about the equal of that of the British specialist and that the salaried American specialist has considerably less buying power. However, the basic British income tax is more than twice our own, and it rises more rapidly.

IV

We come now to certain matters with which British doctors are vitally concerned and about which we in America hear little.

General practitioners say that they like the system because they can order the medicine the patient needs without thinking of his circumstances. On the other hand, in this same connection an eminent specialist told of his experience with a patient who did not respond to any of the antibiotics available in Great Britain. The doctors determined that his life could probably be saved by terramycin, a drug available in Canada and the United States. The family got some through a Canadian friend, but after the fifth shipment the customs officials informed them that they could not bring in any more. Fortunately the patient was by that time at least started on the way to recovery. This represents governmental medicine at its worst. I have seen the same type of thing done in an United States Veterans Administration Hospital after the First World War. No government clerk should be permitted to determine officially a patient's medical needs.

Two other justifiable fears are illustrated by the following imaginary tale:

John Brown had just been licensed as a general practitioner. His family had settled in Dover shortly after the Conquest. There were his roots; there he hoped to set up his surgery (office) in the old family home. He had filed his application with the National Health Service.

"We are sorry, sir," ran the Service's reply, "but Dover is a closed area. There are more general practitioners there than are needed. May we suggest that you consider Yorkshire or Northumberland? There are some areas in those counties where general practitioners are needed."

Yorkshire to him meant mines and mills, smoke and cold, long-row tenements, and meager amenities.

Northumberland to Dr. Brown and his wife spelled barren moors and black-faced sheep, a biting wind and a raw winter, small hamlets and widely scattered homes.

In Yorkshire he could build a panel at 18 shillings ($2.52) per head each year, which with other fees might average 20 shillings ($2.80). In Northumberland, the Government would pay 300 pounds ($840) and perhaps 15 shillings ($2.10) a person and give him a small transportation allowance for patients who lived more than two miles from his surgery.

He had heard of these country practices. One in particular came to his mind. Before the plan was ever devised, a frail young doctor had moved to Somerset where, with few patients and good fees, he had made a nice living. Then came National Health Service and he failed to make ends meet. Northumberland sounded too much like rural Somerset. John Brown chose Yorkshire, but he put his name on a list with twenty-five others who wanted to settle in Dover.

Later he heard of professional deaths and retirements in Dover, but no call came from National Health Service. Vacancies went unfilled until the panels for Dover's doctors grew adequate.

A decade wore away. The children grew up with the clipped speech of Yorkshiremen, which the Kentish grandparents scarce understood.

Finally a call came. With thirty others, eager to take over the remains of a dead man's practice, he appeared before the local board. The son of a Dover practitioner was chosen.

Dr. Brown returned for another dismal wait in Yorkshire's soot. Each time a call came, "another stepped down before him". His disappointed life dragged to an unhappy close in Yorkshire.

Thus the freedom of movement and residence within Britain for which Englishmen have struggled since the plague-filled days of Edward III is once again restricted, restricted not on the level of laborers as it was then, but at the top level of the intelligentsia, not by kings and barons but by the descendants of the very men who won their release from serfdom in the wake of the Black Plague.

The imposition of income ceilings by the Government in respect to dentists carries a very sinister warning of the tragic effects of dictatorships by a monarchy, an oligarchy, a bureaucracy, or a class government.

These are some of the things that concern the older doctors. So far as I know, no doctor has been taken from his practice and "sent to Siberia", so to speak. The squeeze will come on younger men. For their freedom the elders fear.

General practitioners are given the job of caring for the bulk of the sick, but their diagnostic tools (x-rays and laboratory) are taken away, leaving the doctors frustrated, for in the harder cases never can they themselves establish the truth of their shrewdest surmise. Most deliveries in Great Britain are done by midwives. Only when a doctor is called by a troubled midwife does the general practitioner share the joy of welcoming an oncoming life. What in this picture would drive a man to study throughout his life, or make him seek perfection in technique?

In 1951 a general practitioner observed, "It is known that with 4,000 patients (the maximum) 80 items of service (on the average) will be required each day, for six days each week of the year—plus the time required to go from house to house for those patients in bed. Therefore, while it is possible to get a 'good' income with a large list, the great amount of work and the time involved make it impracticable to do 'good' medicine. On the other hand, the doctor with a small list has the time to do good work, but he receives a poor recompense.

"Furthermore, a young, recently qualified doctor who is appointed to a vacant practice can (and does) have transferred to him, in a block, the patients of the outgoing doctor (who is forbidden to sell his practice); he thus acquires at once, despite his lack of experience, the same income as a senior experienced colleague of proved ability having the same number of patients." Consequently, older men would have difficulty adding to their panels when a colleague retires.

Under these multiple difficulties, there is fear that there will be a diminishing flow of capable men into the practice of general medicine, although up to 1952 this fear has not been justified, according to a professor from Edinburgh with whom I talked.

A problem already exists concerning specialists. The close of World War II brought a flood of demands for registrarships (residencies to us). This training usually takes six years. At the present time more men are being prepared for posts as consultants than there are vacancies in the ranks of the consultants. I understand about one fourth of the registrars may expect positions as consultants. The men who fail for consultant appointments can only drop back into general practice where their years of special training are largely wasted, or perhaps they can find their ways to the Commonwealths.

Half the men in each rank of consultants may expect promotion to a higher level. Before they are forty, half this lowest group will have reached their ultimate ceiling of income. Death and retirement from the top ranks are the only means by which able and ambitious young men can escape from the cellar of their hierarchy. America, too, is being overstocked with specialists, but their ceilings are largely personal.

Space precludes telling of the National Health Service offices located in nearly every town through which we passed. The hosts of clerks required to turn the wheels of health and the welfare state are developing a vested interest in the retention of an unproved system. Their salaries must be added to the cost of medical care, whether under governmental agencies as in Great Britain or under the Blue Cross or Blue Shield plans of private enterprise in America. The broader the service, the more fantastic this clerical cost factor becomes.

Great Britain is in a narrow strait: her people too numerous, her land sadly despoiled, her fortunes burned in war, her empire fragmented. Cheerfully her people carry on with few sweets, less meat, and very little heat. Chilblained, without complaint, they sell the very cloth they need. The miracle of Britain is her people.

Britain and America, true to their hardy adventurous stocks, in the midst of socio-economic storm, have each chosen repeatedly to sail boldly into strange uncharted channels. Rarely have their adventures brought them into common port, although every voyage, laid on roughly parallel courses, has brought them into strangely companionate harbors. As the evolution of the monarchy between the Elizabeths closely parallels that which has occurred in the American Government yet differs from it, so the solutions of the common problems of the two peoples will probably bear only a family resemblance.

It is clear that Britain's Health Service is still on its trial voyage. When it finally drops permanent anchors, we may better judge whether we want any part of Britain's present plan or whether it could stand a trans-Atlantic passage to the socio-political climate of America. One can hardly imagine present-day America precipitately adopting a still unproved plan. We cannot, however, withhold admiration from a nation which, in a period of unprecedented trial, seeks to restore and protect the health of her people.

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DISCUSSION

Problems with Trauma to the Hand

(Continued from page 171)

therapy was given for fourteen consecutive days, during which time only slight oedema of the wound was noted. On the twentieth postoperative day suppuration occurred. Similar experiences have convinced us that the extended safe time for primary repair is six hours.

In 1950, we reported our cases of primary tenorrhaphy. Analysis of these cases gave us the same conclusions as those reported by Dr. Flynn. Primary tenorrhaphy of the flexor tendons within the sheath afforded extremely poor results. This was true when only the flexor digitorum profundus tendon had been sutured. During the past two years we have selected cases in which primary tendon-grafting could be done. Our series of such cases is small, but the final results have been considerably better than those obtained by primary repair without tendon-grafting.

Some comment should be made regarding the vascular tree in the hand and its influence, not only upon wound healing, but also upon the ultimate functional result. When both radial and ulnar arteries have been severed at the wrist, or when the volar branches of these arteries have been damaged by crushing injuries, several procedures may be done of which the most successful are novocainization of the cervicothoracic sympathetic ganglia and thoracic ramisection. Our policy has been to novocainize the sympathetic ganglia on the affected side first. When this therapeutic measure has demonstrated the desired effect, the operation of thoracic ramisection for maximum permanent vasodilatation is then considered.

I am convinced that many late complications, such as joint fixation, tissue atrophy, thermal disturbance, and osteoporosis can be prevented by more attention to the adequacy of arterial circulation. Arterial vasospasm in conjunction with oedema of the involved area creates a serious problem. The large dressing on the hand in the immediate postoperative period prevents close observation of the part. It is during this period that novocainization of the sympathetic ganglia would be most beneficial. Thoracic ramisection has great therapeutic possibilities for injuries in the hand. Postponement of this procedure may lead to irreversible pathological conditions resulting in a crippled hand. These complications are frequently seen in spite of detailed surgical technique in the accomplishment of primary or secondary tenorrhaphy or neurorrhaphy or both.

HOSPITAL FOR JOINT DISEASES

The Annual Alumni Conference of the Hospital for Joint Diseases was held on October 30, 31, and November 1, 1952, at the Hospital. The attendance of Alumni, who had journeyed from all parts of the country, and friends of the Hospital who attended the seminars was so great that it was decided to consider plans for an enlarged auditorium to be constructed in the new wing of the Hospital, work on which is expected to begin this spring.

The first day was devoted to a discussion of osteomyelitis. Dr. Joseph Trueta, Nuffield Professor of Orthopaedic Surgery at Oxford, England, delivered a paper on "Acute Hematogenous Osteomyelitis; Its Pathology and Treatment". Dr. Trueta reported that he had used penicillin intramuscularly in the usual doses after a diagnosis of acute osteomyelitis had been made; if in twenty-four hours local pain had not subsided significantly, he considered that operation was indicated. Incision was made over the most tender area and was carried down to bone without stripping of soft tissues from the periosteum. In practically every case a small collection of pus, which he termed "periosteal boil", was encountered. The cortex was drilled; pus was evacuated; and the wound was closed primarily. He reported that, when operating under tourniquet control, he made a series of drill holes in the cortex a short distance from each other, proceeding from a point several inches below the most tender region; cultures taken from these drill holes in the cortex were negative in the most distal portion, but as the drill holes were carried toward the involved area, cultures became positive. In Dr. Trueta's opinion, pus appears very early under the periosteum, and the great danger is that the pus will lift the periosteum away from the cortex, thereby interrupting the blood supply to the involved region; if this condition is allowed to progress, the cortex dies and the osteogenic cells in the periosteum form an involucrum.

Dr. Joseph Buchman presented a series of cases to show treatment in the various stages of the disease; these cases were discussed by Dr. Trueta.

On the night of October 30 Dr. Trueta delivered the Walter M. Brickner lecture, "The Influence of the Blood Supply in Controlling Bone Growth". Dr. Trueta has noted that in metaphyseal osteomyelitis there is no stimulation of bone growth, and in many cases there is a suppression of bone growth. However, in diaphyseal osteomyelitis, there is a significant increase in bone growth. Anatomical studies of the blood supply of long bones revealed that there are three interrelated but distinct modes of blood supply to a long bone,—the periosteal arteries, the nutrient artery supplying the shaft of the bone, and the epiphyseal arteries supplying the ends of the bone. Dr. Trueta believes that osteomyelitis causes thrombosis of the arteries in the location affected; that in diaphyseal osteomyelitis there is increased circulation to the metaphysis—nature's attempt to supply the entire length of the bone with blood through anastomotic channels connecting with the nutrient artery. Realizing that this observation would have profound clinical importance in the stimulation of bone growth, Dr. Trueta carried out a series of experiments in animals in which he mechanically blocked the medullary portion of the diaphysis, thereby cutting off circulation to that region. This was followed by an increase in the growth of the bone, compared to the normal growth which took place in the opposite bone, which had not been operated upon. The medullary plugs which he inserted were effective in occluding the medullary canal for only a limited number of months. For this reason the increment in bone growth diminished and then ceased.

Dr. Trueta has performed similar operations on young patients suffering from limb shortening and was able to duplicate the results which he had produced experimentally in animals. He reported that he is still searching for a more effective method of blocking the medullary canal, in order that bone growth may occur over a more prolonged period of time.

On the morning of October 31, Dr. Anthony F. DePalma, Professor of Orthopaedic Surgery, Jefferson Medical College, Philadelphia, was Chairman of a symposium on shoulder-neck pain; the papers were characterized by a marked diversity of opinion on the pathological changes and etiology of pain in this region and on the various modes of treatment, both surgical and non-surgical. All of those present were enlightened by the discussions, but were left with the impression that much investigation has yet to be carried out in this field until more satisfactory methods of diagnosis and treatment are discovered.

Dr. Charles Sutro discussed the pathological anatomy of the shoulder joint as revealed in autopsy findings. He noted degenerative changes in the rotator cuff, in the synovial fluid of the subdeltoid bursa, and in the cartilage of the head of the humerus and the glenoid. These degenerative lesions were more generalized and more severe in the later decades. Upon investigating the clinical records of these patients, he found no evidence of symptoms or signs referable to the shoulder. He presented a long series of lantern slides depicting vividly the autopsy findings. Dr. Sutro concluded by expressing his inability to correlate the severe changes found at autopsy with the absence of clinical signs.

Dr. James Leland delivered a paper on "Visceral Aspects of Shoulder Pain", particularly that occurring after operations. He found that pulmonary infarcts occurring in the diaphragmatic region frequently are not detectable by roentgenogram, especially by bedside x-rays. This was particularly true in the early stages. He, therefore, suggested that every case of postoperative shoulder-neck pain should be considered to be the result of pulmonary infarction until definitely proved otherwise and that measures should rapidly be taken to prevent subsequent embolization.

Dr. Samuel Kleinberg outlined his treatment of calcareous subdeltoid bursitis. His practice is to treat every patient seen early with immobilization of the arm and mild sedation. In the majority of cases he obtains complete relief in several weeks, regardless of the fate of the calcareous deposit. In chronic cases with limitation of motion, treatment consists in frequent use of sedatives together with physical therapy. Those few patients in whom severe symptoms of pain and limitation of motion persist, in spite of all conservative measures, should, in Dr. Kleinberg's opinion, be subjected to manipulation under anaesthesia. This statement aroused heated discussion. Dr. DePalma decried the use of manipulation under anaesthesia as unphysiological, hazardous, and of no therapeutic value. Dr. Kleinberg countered by stating that, in his many years of experience, he had found this procedure to be effective when all else had failed. Dr. Kleinberg also presented an unusual case of a massive calcareous deposit which had invaded not only the supraspinatus tendon but also the bursal wall and had penetrated even into the head of the humerus. The patient was cured only after the entire calcareous deposit had been excised.

Dr. Julius Neviaser presented "Ruptures of the Rotator Cuff". Ruptures of the cuff commonly occur in association with dislocations of the shoulder and are always present if a fracture of the greater tuberosity is associated with the dislocation. Ruptures likewise occur in injuries of the shoulder without dislocation or fracture. These are seldom seen before the fourth or fifth decade of life and are due to prior degeneration of the tendons of the cuff. The tear commonly occurs near the tuberosity; the patient usually gives the history of a fall or strain of the shoulder and complains of local pain and inability to abduct the arm. As a rule, passive motion of the shoulder joint is normal and relatively painless.

Treatment of partial tears by conservative means, such as a simple sling, gave good results. If, after several weeks, the patient was still unable to abduct the shoulder actively and atrophy of the spinate muscles was apparent, operative repair was indicated. If, on exploration of the shoulder, the cuff rupture was massive and it was impossible to obtain reasonable approximation, then Dr. Neviaser recommended shoulder fusion. In those cases of dislocation of the shoulder accompanied by fractures of the greater tuberosity in which the tuberosity is found to be displaced under the acromion, Dr. Neviaser recommended immediate open reduction with screw fixation of the greater tuberosity into its normal bed.

Dr. Anthony F. DePalma read a paper on "The Frozen Shoulder and Bicipital Tenosynovitis". He said that he was encouraged by the number of clinicians who have accepted the challenge of unraveling the enigma and are approaching the problem from many and different viewpoints. He cited the contributions of the neurologist, the internist, the cardiologist, and the anatomist, and hoped the cooperative efforts of these groups, together with those of the orthopaedic surgeon, would provide a solution to the complex problem.

Dr. DePalma exhibited slides demonstrating the attritional and degenerative abnormalities of the long tendons of the head of the biceps. He reported that explorations in seventy-eight cases of frozen shoulder revealed inflammatory processes of varying intensity in the tendon and tendon-sheath gliding mechanism, varying from filmy, frail, hemorrhagic adhesions to firm, dense strands of fibrous tissue which firmly bound the tendon to the bicipital groove and to the under surface of the rotator cuff. To this he applied the term "bicipital tenosynovitis". He believes that the contributing factors to this syndrome are trauma to the tendon in the bicipital groove, particularly in the motions of abduction and external rotation of the shoulder, abnormalities in the depth of the bicipital groove, such as shallowness and obliquity of the walls and the presence of a supratubercular ridge, and the physiological wear and tear, which explains why the syndrome is more prevalent and more severe in middle life. As regards treatment of frozen shoulder, Dr. DePalma employs rest and hot fomentations; if these are not effective, he transplants the tendon of the long head of the biceps to the coracoid, thus obliterating the gliding mechanism. In his experience, neither x-ray therapy nor cortisone were effective in alleviating the disability of the painful frozen shoulder.

Dr. David Goldberg presented his study of the scalenus anterior syndrome. In his opinion, the patients' disability was caused by compression of the brachial plexus between the scalenus anterior muscle and the transverse process of the seventh cervical vertebra. The circulatory changes in this syndrome, in his opinion, are caused not by pressure on the subclavian artery, but rather by irritation of the postganglionic fibers entering into the brachial plexus. He presented seven cases of shoulder-arm pain which, in addition, revealed severe localized tenderness to pressure over the scalenus anterior muscle above the clavicle. If the patient responded to a succession of brachial-plexus and stellate-ganglion blocks and had recurrence of pain uniformly relieved by these blocks, then Dr. Goldberg sectioned the scalenus anterior muscle. In seven cases so treated, relief of pain was dramatic and lasting.

Dr. Abraham Meyers discussed degeneration of cervical intervertebral discs due to whiplash injury causing shoulder-neck pain. The patients presenting this lesion gave histories of whiplash injuries in the past occurring in automobile accidents and falls from a height. Months and sometimes years after injury, symptoms referable to disc degeneration occurred. Characteristic x-ray findings of narrowing of an intervertebral space in the lower cervical spine and flattening of the normal cervical lordosis substantiated the clinical impression.

Dr. Robert B. Portis reported on "The Place of Deep X-Ray Therapy in the Management of Shoulder-Neck Pain". He found that in a high percentage of cases relief from pain results from x-ray therapy. He cautioned against excessive amounts of radiation, stating that the minimal dosage should be used so that, in case of recurrence of pain, the same form of therapy could be used without danger of radiation necrosis.

Dr. Albert M. Betcher described the role of regional anaesthesia in cases of intractable shoulder pain. In each instance there was interference with motion of the shoulder and, therefore, inability to carry out normal function. Nerve-block therapy relieved pain and thus permitted a greater range of motion. It also permitted other therapeutic measures, such as traction and physical therapy, to be tolerated if preceded by nerve-blocking.

Nerve-block therapy is of value in intrinsic conditions of the shoulder, such as acute and chronic subacromial bursitis, myalgia, partial capsular tears, lesions affecting the long head of the biceps, old fractures, direct injury to the shoulder without fracture, reflex sympathetic dystrophy, and metastatic carcinoma of the shoulder girdle. The extrinsic conditions benefited by nerve block are cervical osteo-arthritis, postcoronary occlusion, scalenus anterior syndrome, and occupational and idiopathic shoulder pain.

Two hundred and fifty patients with shoulder pain were treated with nerve block by local infiltration, trigger-point injections, intravenous procaine infusions, cervical somatic block, brachial-plexus block, suprascapular-nerve block, and stellate-ganglion block for a total of 1,628 nerve blocks in a five-year period. The more acute the conditions and the shorter the duration of symptoms, the more effective were the nerve-blocking procedures. The acute conditions required fewer nerve blocks, while the chronic conditions required repeated blocking over a longer period of time. The results indicated that nerve-block therapy was valuable in relieving certain conditions of shoulder pain and impaired mobility.

During the afternoon session on October 31 there was a panel discussion on myelography in relation to the diagnosis and treatment of low-back pain under the chairmanship of Dr. Maurice M. Pomeranz, Radiologist of the Hospital. He was presented with a plaque by the Alumni of the Hospital in gratitude for the many years of teaching and encouragement he had given them. Dr. David Bosworth and Dr. Leo Davidoff were the principal speakers. Dr. Bosworth presented his opinion that myelography was not indicated when there was a presumptive diagnosis of herniated intervertebral disc, because of the not inconsiderable number of patients who suffered distressing sequelae following the injection of pantopaque. He stated that, if he thought that the patient's low-back pain was the result of possible tumor of the cauda equina, he referred the patient to a neurosurgeon for myelography and treatment. Dr. Davidoff was of the opinion that, whereas there were distressing sequelae following myelography, these sequelae were numerically not significant and the morbidity was slight except in extremely unusual cases, and that myelography afforded information which was otherwise unobtainable.

Following the discussions of Dr. Bosworth and Dr. Davidoff, Dr. Pomeranz exhibited roentgenograms of myelographic studies which illustrated sources of common error. He stated that throughout the years, as his experience in interpreting myelograms had increased, his percentage of error correspondingly had decreased. He also presented a series of myelographic studies which brought out specific points. The correct localization of a herniated intervertebral disc could be established only on the basis of myelograms. He presented a case which clinically had unequivocal signs related to the eleventh thoracic vertebra. Myelograms revealed herniation of a disc between the fifth lumbar vertebra and the first sacral segment. At laminectomy the disc in this region was found to be extruded and was removed; the patient had complete relief of symptoms. He also presented myelographic studies of cases in which the signs unequivocally pointed to lesions on one side. Myelograms revealed that the disc protruded on the opposite side. At laminectomy, the side of symptoms and signs was operated on first and no disc was found. Laminectomy performed on the opposite side, the side on which myelograms had revealed a protrusion, disclosed an injured disc; following excision, the patient had complete relief of symptoms.

He showed a series of myelograms of patients who had had simple laminectomy and laminectomy with fusion in whom there were recurrences of symptoms following surgery. The reason for recurrence of pain could not be explained until subsequent myelography revealed a disc injury at a higher site, a bony spur projecting into the neural canal, or an arachnoiditis. He concluded his demonstration by showing x-rays of pseudarthroses, some in patients exhibiting recurrence of pain, others in patients without any symptoms.

The morning session on November 1 was devoted to presentations by Alumni and members of the Staff of the Hospital. Dr. Arthur F. Abramson delivered a paper on "Rehabilitation of the Arthrotomized Knee". He had carefully and painstakingly analyzed functional results following arthrotomy in a group of patients who had rigorously practised quadriceps-resistance exercises following surgery, as contrasted with a series of patients who had not. He convincingly demonstrated the importance of quadriceps exercises following arthrotomy of the knee.

Dr. Raphael R. Goldenberg presented a paper on "Low-Back Pain Simulating Herniated Intervertebral Disc". In this series of interesting and illustrative cases, patients had classical symptoms of herniated intervertebral discs, but careful examination, including x-ray studies, revealed specific lesions totally unrelated to a herniated intervertebral disc. He stressed the importance of complete examination and cautioned against diagnosing a herniated intervertebral disc, except after carefully eliminating all other possible sources of pain which might simulate disc protrusion.

Dr. Melvin Jahss gave a preliminary follow-up report on congenital coxa vara. He showed good results following subtrochanteric osteotomy.

Dr. Sydney Sewall reported a series of cases demonstrating a "Modification of the Irwin Procedure for Tight Fascia Lata following Poliomyelitis". Patients whom he treated had demonstrated multiple deformities including scoliosis, fixed pelvic obliquity, flexion-abduction contractures of the hip, and deformities about the knee. He demonstrated that no one standard procedure could be employed for the rehabilitation of these patients and that a combination of soft-tissue surgical procedures must be employed.

Dr. Joseph Buchman and Dr. Richard Fenton presented a paper on "The Use of Isoniazid in the Treatment of Bone and Joint Tuberculosis—A Preliminary Report". The authors felt that, if isoniazid was effective against the tubercle bacillus, it could be used in conjunction with surgery to eliminate the disease, much as terramycin and surgery are used in the treatment of non-tuberculous osteomyelitis; since, in all but the very acute lesions, the tuberculous foci are caseous and walled off from the blood supply, the drug alone would not be effective because it would not reach the offending organisms. Thus it was postulated that, with isoniazid and local excision, motion could be retained in involved joints; this method would make unnecessary the use of fusion or rest or both as a means of allowing the host to cope with the disease.

Six cases were presented; in all the diagnoses had been proved by culture or biopsy, or both. Roentgenographic studies showed steady improvement, with restoration of the diseased areas.

The speakers concluded that it was too early to tell, but they hoped that in the future the use of the antituberculosis drugs would give increased opportunity to restore function in cases of tuberculosis of the bones and joints.

Dr. Leonard R. Rubin outlined "Plastic Procedures for Congenital Abnormalities of the Hand". His paper first discussed general considerations such as: handling skin with great gentleness; avoiding skin tension in closing wounds; using fine suture material; using soft-pressure dressings; and in mobilization of the hand for a maximum of ten days.

The specific conditions discussed were: the supernumerary digit, in which the important consideration is to turn a skin flap on to the dorsum of the hand when the digit has been amputated; and the web finger (syndactylism), in which it is important to have a fatty skin flap so placed as to avoid secondary contracture of the base of the web space. A V-flap on the dorsum and a V-flap on the volar side of the web, created from the proximal portions of the skin composing the web could be laid side by side to form a W. With the base of the web space secured at the level of the metacarpophalangeal joint, the defects at the side of the fingers could be closed with thick split skin grafts. These grafts had to have extending darts made at each interphalangeal joint to avoid flexion bow-string contracture.

Dr. Rubin also discussed the contracted annular ring involving fingers. To avoid amputation by these ring contractures, Z-plasties had to be done for complete cures. Finally, he discussed fused fingers. Treatment depended upon the presence of bony structures. The soft tissues could be dissected in such a way that flaps of skin and fat were left which should be turned on the volar side of the hand. Split skin grafts could be placed on all exposed dorsal areas.

Dr. Isadore Zadek discussed treatment of recurrent dislocation of the shoulder, presenting the various methods of surgical repair and the end results of treatment in which the various procedures were used.

Dr. Howard Rosen and Dr. Herbert Sandick reported a study of "Tibial Torsion", including diagnosis and treatment.

The afternoon session of November 1 was devoted to a symposium on the autonomic nervous system in relation to pain. Dr. Joseph Pick discussed "Anatomical Aspects of Sympathetic Denervations of the Extremities"; Dr. Walter F. Ryker discussed "The Pharmacology of the Peripheral Synapse"; and Dr. Fritz Cramer spoke on "The Autonomic Nervous System in Clinical Practice—the Manifestations of Central and Peripheral Affections and Their Treatment."

On Saturday night, November 1, the annual dinner-dance was held at the Colonnade Room, Essex House. It was attended by the Alumni, the Staff of the Hospital, the administrative officers of the Hospital, members of the Board of Trustees, and invited guests. The address of the evening was by Dr. William A. Rogers, Editor of *The Journal of Bone and Joint Surgery.* He traced the development of orthopaedic surgery and of the Hospital for Joint Diseases during the past fifty years. The strap, buckle, and brace technician, he noted, has been replaced by the surgeon who is skilled in the prevention and treatment of disease in every form as it affects bones, joints, muscles, and nerves by every accredited therapeutic agent and who works for the subsequent rehabilitation of the patient. Exact knowledge has replaced empiricism and the basic sciences of anatomy, physiology, and chemistry have become the backbone of our specialty. Dr. Rogers traced the history of the Hospital for Joint Diseases through this development. He praised the vision of Dr. Henry W. Frauenthal, the founder of the Hospital, who established services of internal medicine, pediatrics, neurology, and general surgery to function as integral parts of the organization to collaborate with the orthopaedic service. From this collaboration a spirit of investigation was instilled and he praised the Hospital for its contributions to orthopaedic surgery. He had tabulated 165 articles which members of the staff had published in the past twenty years in *The Journal of Bone and Joint Surgery* alone; during this same period Alumni had published forty-four articles in the same *Journal*. Dr. Rogers stated what he believed to be the three main objectives of a good hospital—service to the community, education of its resident and attending staff, and research. He complimented the Hospital for Joint Diseases upon its devotion to these ideals and concluded by expressing the hope that the Hospital would continue its tradition and thus continue to advance the development of orthopaedic surgery.

NEW JERSEY ORTHOPAEDIC SOCIETY

The Seventh Annual Meeting of the New Jersey Orthopaedic Society was held at the Kessler Institute for Rehabilitation, West Orange, New Jersey, on October 11, 1952. Officers for the coming year were elected as follows:

President, Paul J. Finegan, M.D., of Trenton;
President-elect, Henry H. Kessler, M.D., of Newark;
Secretary, William Kruger, M.D., of Newark; and
Treasurer, Harold T. Hansen, M.D., of South Orange.

The scientific program included presentation of five papers. Dr. Robert Brendze, of the Jersey City Medical Center, presented a paper on "Early Experiments with the Judet Arthroplasty". This paper dealt with a discussion of twelve cases of Judet arthroplasty and an analysis of the end results of these cases. Dr. Brendze's paper won the prize offered by the New Jersey Orthopaedic Society for the best paper prepared on an orthopaedic subject by a resident during the past year.

Dr. Ludwig Guttmann, Director of the Ministry of Pensions Spinal Injuries Centre at Aylesbury, Bucks, England, presented a paper on "Rehabilitation of the Paraplegic". Dr. Guttmann presented a broad view of the development of services for the rehabilitation of paraplegics as practised at the Centre in England. He stressed the necessity for teamwork among specialists and pointed out that 74 per cent. of the patients at his Centre have been sufficiently rehabilitated, both physically and vocationally, to be either partly or completely self-supporting.

A clinic on congenital defects was held in the afternoon. Dr. Douglas P. Murphy, of the University of Pennsylvania in Philadelphia, presented a paper on "Statistical Aspects of Congenital Deformities". The paper was based on a study made by the author in the Philadelphia area to determine the incidence of congenital defects. He pointed out that the relative frequency of congenital malformations is greater in the white than in the negro race. The maternal age has a definite influence upon the frequency of the malformations, and a relationship was demonstrated between a long period of relative sterility and the birth of a congenitally malformed child. Data were given regarding the frequency of the birth of more than one congenitally malformed child to the same parents, with reference to the frequency with which the same type of defect appeared in siblings.

Dr. Salome Gluecksohn-Waelsch, of the Department of Zoology of Columbia University, New York City, presented a paper on "The Genetic Aspects of Congenital Deformities". Dr. Gluecksohn-Waelsch pointed out that studies on short-tailed mice have been significant with reference to the incidence and development of congenital defects in humans. She indicated that identically appearing congenital defects may owe their existence to entirely different genetic conditions; similar defects may arise as a result of different embryonic disturbances. From the point of view of therapeutic approach, it is important to realize that the effectiveness of treatment depends on the morphological or physiological nature of the congenital defect and the mechanism responsible for it and not on the sporadic as against the hereditary nature of the defect.

Dr. Robert F. Korns, of the State of New York Department of Health, Bureau of Epidemiology and Communicable Disease Control, presented a paper on "The Epidemiological Aspects of Congenital Defects". The relationship between epidemics of German measles (rubella) among pregnant women early in the pregnancy and the birth of children with congenital defects to these women subsequently was discussed.

Following the presentation of these papers, Dr. Kessler conducted a demonstration clinic to illustrate the techniques and methods of rehabilitating children who were born armless, legless, or both. Congenitally deformed children between the ages of one and twelve years were seen at the Clinic.

AMERICAN SOCIETY FOR SURGERY OF THE HAND[*]

The Seventh Annual Meeting of the American Society for Surgery of the Hand was held in Chicago on Friday and Saturday, January 25 and 26, 1952. Sessions were held at the Palmer House on Friday and at Northwestern University on Saturday. The Meeting was held under the presidency of Dr. Michael Mason.

A business meeting was held on Friday, January 25, 1952, at the University Club. After cocktails and dinner, Dr. Sterling Bunnell showed colored films of big game animals in Alaska. Dr. Eldon C. Weckesser was elected to membership: The President for 1952 is Dr. William H. Frackelton. The officers elected were: Dr. Darrel T. Shaw, President Elect; Dr. Lot D. Howard, Jr., Vice-President; Dr. Joseph H. Boyes, Secretary-Treasurer; Dr. S. Benjamin Fowler, Historian; and Dr. Harvey S. Allen, Member of the Council.

FRIDAY, JANUARY 25, 1952

The scientific sessions were opened on the morning of January 25, 1952. Summaries of the papers presented at these sessions follow:

Deformities of the Hand Incidental to Pathological Changes of the Extensor and Intrinsic Muscle Mechanisms. DR. J. LEONARD GOLDNER [1] emphasized that physiological function of the hand depends upon coordination between the intact intrinsic-muscle mechanism and the extrinsic muscles. Injury to any part of this system results in deformity. Trauma to the central slip of the extensor tendon, to the lateral bands anywhere along their course, or to the main dorsal hood leaves an imperfect digit. Ischaemic contracture of the intrinsic muscles or tendons, thermal contracture of the dorsal tissues, and contracture of the lateral bands or collateral ligaments leave typical changes in the hand. Roller injuries, in particular, result in severe damage to the extensor apparatus.

The "intrinsic-minus" (claw) hand may occur if adequate splinting and definitive surgery are not done at the proper time. Long-standing, rigid claw deformity cannot be treated in the same way as recent contractures. Metacarpophalangeal joints in extreme hyperextension of long duration in conjunction with absent intrinsic muscles may be handled expediently by joint fusion. Metacarpophalangeal joints less severely hyperextended, with functioning intrinsic muscles, can be improved by the adequate excision of collateral ligaments, the freeing of all dorsal tissues, and the stripping of the volar plate. It is essential to excise the thickened deep fascia over the distal end of the metacarpal in conjunction with the other procedures. Active and passive immobilization in flexion was advised for six or eight weeks following the release of the extension contracture.

If joint function can be restored at the metacarpophalangeal articulations, even though the dorsal hood has been severally damaged, free tendon grafts can be inserted in the deep fascia over or in the bone of the proximal phalanx in order to increase the strength of the grasp. If the dorsal hood has been destroyed and the joint has been affected, fibrous ankylosis or osseous fusion leaves a desirable end result. If the dorsal hood is intact and the extensor tendons have been destroyed, it is desirable to correct the extension contracture by the adequate excision of scar tissue and collateral ligaments, followed by replacement of the extensor tendons.

In burns, a fixed "button-hole" deformity can be changed to a mallet-finger deformity, which allows better flexion, if other reconstructive measures cannot be done. In old burns, it is occasionally important to maintain a slight "button-hole" deformity, if this position is consistent with a specific occupation. When severe destruction has occurred in the skin, dorsal tendons, and even the joints, following a thermal injury, fusion of the middle and distal interphalangeal joints is a useful procedure, particularly when severe flexion or extension deformities had resulted.

The "intrinsic-plus" hand, resulting from contracture of the intrinsic muscle mechanism from any of a number of causes, can be improved by advancing the intrinsic muscles in the metacarpal region or by sectioning the lateral bands opposite the proximal interphalangeal joints. The lateral bands were sectioned when there was little hope of regaining active flexion from any other procedure. Dr. Goldner stated that certain hands might have the appearance of "intrinsic-plus" hands, but that the proximal segment of the intrinsic mechanism may not be involved. He felt that it is necessary to differentiate a contracture of the intrinsic muscles and fascia, contracture of the lateral bands in the digits only, contracture of both the extensor mechanism and the lateral bands, and changes in digits, caused by pathological changes in the joint, resulting in hyperextension.

(For discussion of Dr. Goldner's paper by Dr. S. Benjamin Fowler [2] and Dr. Lot D. Howard [3], see page 131.)

An Evaluation of Skin Grafts for Hand Coverage. DR. S. M. DUPERTUIS [4] said the fact deserves re-emphasis that immediate or early skin grafts can prevent, and the proper graft to replace a contracted scar can correct, most of the disability following the healing of a burn, avulsion, or even laceration of the hand. Certain observations concerning the skin grafts frequently employed in general plastic surgery were presented and their application in reconstructive surgery of the hand was evaluated.

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[*] Received for publication on October 25, 1952.

[1] Duke University School of Medicine, Durham, North Carolina

[2] 1921 Broadway, Nashville 4, Tennessee

[3] 516 Sutter Street, San Francisco 2, California

[4] Medical Arts Building, Pittsburgh 13, Pennsylvania

Surface defects without the benefit of skin grafts heal in the quickest and most economical manner possible, for granulation tissue by contracture reduces the area to be covered by the ingrowing epithelium; but thin epithelium over fibrous tissue alone results, since the dermal layer which provides elasticity to the skin does not regenerate.

Dr. Dupertuis emphasized the preferred use of adjacent tissues to close the defect as a fundamental principle of reconstructive surgery. On many occasions adjacent tissues can be applied to the hand for improved functional results. A Z-plastic correction of linear contracted scars on the hand can give excellent functional results, but because of the restricted surface area, this method has definite limitations when it is applied to the fingers.

The V-Y procedure for lengthening a longitudinal contracture of the finger is of limited value, since a straight longitudinal portion of the scar remains and contracture can recur. An adjacent pedicle graft from the side of the finger to cover a flexor defect provides coverage with better sensation and protective thickness on the working surface than does a free graft. Flaps taken from adjacent normal fingers or from the palm to replace a contracted scar on the finger may be satisfactory, but occasionally the scar of closure or the graft covering the donor site may produce considerable disability. He thought that Bunnell's technique of "filleting" a useless finger provides excellent tissue for replacement of a scar defect.

Dr. Dupertuis believed that full-thickness skin grafts from the back, chest, and upper abdominal regions in the adult usually do not take well because they are too thick. Experience had demonstrated to him that a full-thickness skin graft from the lower abdomen, groin, or other comparable thin areas provides a better graft than does the same thickness taken as a split-thickness skin graft from the thicker skin on the back. The best application for full-thickness skin grafts on the hand is to cover smaller areas and particularly to replace superficial contracted scars of the palmar surface.

For the successful take of a free graft, immobilization is mandatory, even though pressure is not necessary. Pressure dressings for grafts are preferred, however, and are employed routinely, because they aid in healing and assist in the immobilization of the graft. Since the object in replacing a contracted scar by a skin graft is to eliminate or to minimize the contracture, the additional operating time necessary to secure a precise and accurate approximation of the edges is well justified, for there will be a finer linear scar about the graft and hence a quicker return of function.

Split-thickness skin grafts are most useful when they are applied to larger defects on the arm and particularly to the dorsum of the hand, where minimal shrinkage or contracture is observed. Split-thickness skin grafts applied to the dorsum of the hand or arm in children will grow and will increase in size. In two of his patients whom he reviewed ten years after the application of the graft, he found that the stretching and wrinkling over the knuckles had assumed a nearly normal configuration and appearance. Most free grafts are not a perfect match in color or texture, and usually show some degree of pigmentation, although they become almost as pliable as the normal skin. The normal venous network on the dorsum of the hand should be preserved at operation, and it later presents a natural appearance beneath the healed split-thickness skin graft. In patients who show evidence of early x-ray dermatitis, when replacement is necessary, larger split-thickness skin grafts should be applied than appear to be indicated, since x-ray dermatitis is a progressive, degenerative lesion and the extension about the periphery will not become evident until many years later. He stressed that there should never be an indication to employ small deep grafts upon the hand, since they are unsightly and do not supply a good functional coverage.

He preferred the closed pedicle graft for hands. This graft is provided by the tubed pedicle or the open flap with split-thickness skin graft, and is applied to all raw surfaces in the manner described by Macomber. If the donor site of any pedicle is not closed, it should be grafted immediately in order to prevent absorption through the pedicle from the adjacent open granulation area. The one-stage tubed pedicle, as described by Shaw, is very desirable and has many applications. He emphasized that excess fat can be removed safely from abdominal pedicle flaps and that all grafts should be thinned before being applied to the hand. The pocket flap in which the hand is buried beneath the abdominal skin should be condemned as a procedure of choice, because of the foul discharge and contamination which accompanies this procedure.

In treating traumatic avulsions, he favored immediate application of a split-thickness skin graft to secure healing; when the occasion demands, he advocated the immediate application of an abdominal pedicle flap to the defect. No open wound should ever be left to heal with scar.

In deep burns of the dorsum of the hand in which the intricate mechanism of extension may have been severely damaged by prolonged absorption from granulation surfaces, he suggested surgical excision of the slough and the application of a split-thickness skin graft in ten to fourteen days. The universal metal splint, described by Allen and Mason, permits relaxation of the hand in the position of function, and the pressure-dressing method of immobilization remains the treatment of choice. In most instances, a split-thickness skin graft of intermediate thickness will provide good functional coverage, and any healing scar surrounding a granulation area should be removed to normal skin to minimize scar contracture on the borders of the graft.

Dr. W. Brandon Macomber[5], discussing the report, emphasized a few additional points. Wrinkling of calibrated grafts applicable in hand surgery had been minimal in his experience. Split-thickness skin grafts had proved preferable to full-thickness skin grafts for the resurfacing of the palm. The mortality of the full-thickness skin graft was greater than that of the split-thickness skin graft. He pointed out that there are certain factors which may cause the wrinkling of a split-thickness skin graft: (1) The graft may be too thin, as mentioned by Dr. Dupertuis; (2) there may be failure to remove all of the deep scar tissue (scar breeds scar and a fine film of scar left will definitely cause wrinkling of the graft whether it be a split-thickness skin graft or a full-thickness skin graft); (3) there may be failure to put the graft on without normal skin tensions; (4) there may be inadequate pressure which prevents the graft from conforming to all the depressions; (5) the pressure dressing itself may cause the graft to wrinkle — and this will be permanent. He stressed that the splint advocated by Allen and Mason will help to keep the pressure dressing from wrinkling the graft.

In acute burns, wrinkling of split-thickness skin grafts often occurs after healing has taken place. Complete avulsion of the scar-forming granulations and even pressure on the split-thickness skin graft will prevent future wrinkling and will give a more pliable graft.

The importance of a good skin covering in acute wounds cannot be overemphasized.

Dr. Harvey S. Allen [6] said it is so often forgotten that a primary wound, even though contaminated, will very readily accept a split-thickness skin graft to close the gap and to convert the open contaminated wound into a closed wound. He had used split-thickness skin grafts in treating amputation of the finger tip and avulsion of the hand from roller injury and had found them to serve satisfactorily for complete function.

He said that the full-thickness skin graft is certainly a most exacting graft and that it gives the most satisfactory results. He pointed out that it is often not necessary to go through the exacting regimen necessary to apply a full-thickness skin graft. He recognized that the mortality of full-thickness skin grafts is rather high. However, he felt that, if a case has been properly selected and the wound is clean before the scar tissue is removed, it is an acceptable site on which to place a full-thickness skin graft.

In many instances one must decide by the depth of the burn that a split-thickness skin graft may not suffice in treatment of a burn on the dorsum of the hand. There are many cases in which the entire thickness of the hand may have been burned away and it would be foolish to attempt a split-thickness skin graft, except to obtain immediate closure of the wound. In deeper burns a full-thickness skin graft should be used later.

Another phase of the problem of surgery of acute burns which he discussed is the removal of only burned tissue which is necrotic. He felt that it is important to remove this necrotic mass in order to avoid infection. Yet, one cannot be sure of the exact depth of the burn initially. After a simple cleansing, a compression dressing and splint are applied until the patient is stabilized. Usually on the fifth day, it is quite obvious what burned tissue is dead and what is not. Under anaesthesia, the entire necrotic thickness is removed. There is minimal bleeding. A split-thickness skin graft is then applied which converts the open wound into a closed wound. The hand is placed on a splint with a compression dressing. After the hand has become stabilized through use, the split-thickness skin graft is replaced with a full-thickness graft. It is at this time that incisions should be placed in order to avoid contractures.

Arthrodesis of the Hand. III. Wrist Fusion. Dr. William H. Frackelton [7] stressed that painful motion, improper alignment, lack of stability in the joints of the hand are requisites for correction. When intrinsic restoration is impossible, painless stability and functional position will accrue from surgical fusion of the joint. When injury or disease has irrevocably robbed a joint of its motor action, surgical stability can assuage the loss. When tendons must be transferred for motion of higher functional priority, the donor-joint area may demand arthrodesis as needed recompense.

It was pointed out that the specific indications for wrist fusion can be considered for deformities, intrinsic or extrinsic to that joint. He called attention to the fact that intrinsic wrist deformities are of congenital, of arthritic, or of traumatic nature. The congenital absence of radius or ulna usually requires wrist fusion to overcome angulatory deviation and instability.

Arthritic changes in the wrist are the aftermath of infectious, degenerative, or traumatic processes. Tuberculosis is treated in the quiescent stage by surgical fixation, arthroplasty being contra-indicated for fear of reactivation of the disease. Pyogenic infections may so damage joint surfaces as to require fusion for relief of pain and restoration of correct position. The removal of offending degenerative navicular or lunate bones may not be done in time to prevent reciprocal destruction of adjacent joint surfaces; fusion for this accompanying arthritis relieves pain and weak wrist action. Traumatic arthritis, fostered by external injury and progressing to a crippling degree, was improved functionally by arthrodesis.

He pointed out that extensive loss of wrist structure, which almost invariably results from trauma of an explosive nature, occasionally from tumor extirpation, may be treated by bone-grafting and joint obliteration.

Of the extrinsic deformities of the wrist in which arthrodesis is applicable, those caused by spastic paralysis and those caused by flaccid paralysis were considered. The use of wrist fusion for spastic patients has been decried. Increase in deformity was offered as evidence against arthrodesis. It is true that splinting and exercise are indicated for reasonable lengths of time in the care of deformities caused by spastic paralysis. That the press of social and economic needs and the leveling off of improvement by conservative treatment made the spastic youth a candidate for surgery was stressed. Tendon transfers are seldom effective in the spastic patient; the offending cerebral imperfection is unaltered by such manoeuvres. By them the deformity may be reversed and intensified rather than diminished. Wrist fusion, together with arthrodeses of the thumb and proximal finger joints, may sufficiently offset the spasticity to allow effective finger motion.

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[5] 149 Washington Avenue, Albany 6, New York

[6] 154 East Erie Street, Chicago 11, Illinois

[7] 324 East Wisconsin Avenue, Milwaukee 2, Wisconsin

Extensive loss of motion from poliomyelitis, damage to two of the three forearm motor nerves, or local muscle-tendon damage may force the decision as to where available functioning motor units can be applied most advantageously. If two or more separately functioning long tendons exist, wrist fusion, with or without other hand arthrodeses, can free these tendons from former obligations and will allow one to extend the digits and the other to flex the digits. Additional activated tendons for thumb opposition give further increments of useful hand motion.

The techniques described by Bunnell, Campbell, and Smith-Petersen were endorsed as proper guides for the operation. It was pointed out that supplementary bone-grafting assures more successful and rapid union and that its use is almost universally warranted. An iliac autogenous graft is preferred. The greater permeability of autogenous bone and its more rapid integration in fusion removed from bank bone much of its appeal. The use of a graft taken from the radius provided the autogenous bone from a single operative field. Blount's modification of Campbell's procedure was recommended as suitable. He removed from the exposed dorsum of the distal portion of the radius, a tapered and undercut section, the greater width of which was cut distally. He then chiseled a socket in the carpus. Into this the reversed bone section was set, and proximally it was set into the slot in the radius.

Larger defects he replaced by iliac blocks; exceedingly long defects he replaced by tibial grafts. Carpal sockets and overlays on the radius satisfied his requirements for position and contact; Kirschner wires or bone screws were used to give added fixation.

Postoperatively, he found that troublesome swelling could be avoided by combining a compression dressing to the hand and wrist with a cast. The latter maintained the forearm in mid-position between supination and pronation and included the elbow in right-angle flexion. In a week, he replaced this with a better fitted cast without the compression-dressing layer. He shortened the cast to allow free elbow motion within two months. He felt that replacement of the cast by a molded leather hand-forearm brace with strengthening volar steel strips was elective.

In discussing this paper, **Dr. Harold B. Boyd** [8] said that, when the wrist is involved, fusion is usually the operation of choice. In most patients with non-union of the navicular and secondary arthritic changes in the wrist, fusion is the operation of choice; however, in some who are engaged in performing fine work, resection of the proximal row of carpal bones (not including the pisiform) may be preferable. This operation often results in a satisfactory "semi-arthroplasty" of the wrist.

For giant-cell tumors of the lower end of the radius with sufficient destruction to require resection, an excellent substitute for the lower end of the radius can be obtained by the transplantation of the upper end of the fibula. This avoids arthrodesis of the wrist. He felt that it is advisable, if the wrist is to be fused in a patient with cerebral palsy, to immobilize the wrist in the proposed arthrodesed position with a light cast or a brace for several weeks or months before the operation. This will give the patient and the surgeon an opportunity to determine whether or not the new position will be satisfactory. The result following fusion of the wrist in a patient with cerebral palsy cannot always be predicted before surgery.

Dr. T. Campbell Thompson [9] pointed out that during the last ten years at the Hospital for Special Surgery and in the last four years at the Veterans Hospital, there had been a total of sixty-one wrist arthrodeses done for various purposes. The average age was twenty-one. The largest group, 28 per cent., were done for spastic paralysis. Although many of these spastic patients will never use the bad hand, he was convinced that the cosmetic result alone is worth while. Of the rest, 15 per cent. were done for poliomyelitis; 11 per cent., for Erb's paralysis; 11 per cent., for fractured navicular; 8 per cent., for tuberculosis of the wrist; 8 per cent., for arthritis or infections of other types; 7 per cent., for other types of fractures and deformities; 5 per cent., for Volkmann's paralysis; 2 per cent., for tumors of the lower end of the radius; 1 per cent., for Madelung's deformity; and 1 per cent., for wrist-drop. Only eleven were done for pain. Almost all had a flexion deformity; many also had some radial deviation. He emphasized that ulnar deviation is quite helpful and that in spastic paralysis the wrist should be so fixed that there is ulnar deviation of a considerable degree. He pointed out that these patients were able to get the thumb opposite the palm only if the wrist had been placed in ulnar deviation. This position improved their ability to open the hand.

The methods of fixation used were as follows: thirty-two were done with a radial graft turned end-to-end. The lower end of the ulna was excised, when it was too long, in order to gain ulnar deviation. When this was done, the ulnar fragment was used as a graft. In five, iliac grafts were used; in six, bank bone. The great majority of arthrodeses fused. He stated that the period of immobilization varied from three to six months.

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[8] 869 Madison Avenue, Memphis 3, Tennessee

[9] 321 East 42nd Street, New York 17, N. Y.

He was unable to obtain follow-up reports on thirteen patients. Thirty-one had excellent results. There were three in whom fusion was not solid; but the patients were very well satisfied, and the position of the wrist was satisfactory. There were two who had sufficient recurrence of the flexion deformity to give a poor result.

There was one interesting case, a boy of twenty-one who had had poliomyelitis at the age of four which had resulted in marked paralysis and flexion deformity. Median-nerve neuritis had developed following correction of the flexion deformity, even though there had been a resection of the carpal bones. He stressed that it is important to remove enough bone so that there will be no tension on the median nerve. One of his patients with poliomyelitis had had both wrists fused.

He called attention to the fact that, in some patients in whom the wrist has been acutely flexed and for whom fusion in a little extension is desirable, it is quite possible to make a Z-incision instead of a linear one, with the transverse portion of the Z across the wrist. Thus, when the wrist is extended, the Z can be closed in the opposite direction. This gives a very loose and pleasing closure; and by it the patient is made comfortable, for it allows for postoperative swelling.

A New Procedure for Treatment of Luxation of the Distal End of the Ulna. DR. FREDERICK LEE LIEBOLT [10] pointed out that stretching or tearing of the radio-ulnar ligaments produced luxation of the distal radio-ulnar joint and allowed the lower end of the ulna to move anteroposteriorly or forward and backward. The condition was described in 1906 by Mouchet, of France, when he said, "The head of the ulna fluctuates like a piano key". It was stressed that this excessive relaxation produces instability and disability, particularly in persons who use their wrists extensively.

The condition is the result of trauma, most frequently that of extreme pronation or of extreme supination of the wrist. He urged, in order to understand the mechanism by which the distal end of the ulna is originally dislocated, that it be remembered that the radius, carpus, and metacarpus are one unit, bound together by strong ligaments. Contrariwise the ulna is poorly situated at the wrist and is not a part of the joint: it is held loosely in position by the weak, scattered fibers of the anterior and posterior ligaments; by the thin, often congenitally perforated intra-articular fibrocartilaginous disc; and by the strong ulnar collateral ligament attached to the small, easily fractured styloid process of the ulna. It follows, that extreme rotation of the unit comprising the radius, the wrist, and the hand will, in overpronation, produce a backward luxation of the ulna and, in oversupination, will produce a forward luxation of the ulna.

He stressed that the mechanism of injury in those cases associated with fracture consists in the ulnar collateral ligament holding under the force of an impact and producing a fracture of the ulnar styloid process. This in turn allows the force to be transmitted directly to the radio-ulnar articulation; the thin anterior and posterior ligaments are either torn or stretched. The end of the ulna thus becomes unattached and freely moveable. Lippmann states, "In approximately one of every nine cases, Colles' fracture is followed after the healing period by laxity of the radio-ulnar joint".

The treatment of chronic luxation of the distal end of the ulna, during the past two centuries, has been quite varied. Although there was insufficient time to discuss each procedure individually, he presented in summary five types of external support, six types of bone operations, six types of internal metallic support, and sixteen types of internal soft-tissue support, none of which, however, is the same as the method he presented.

He advocated strongly that the resection of the distal end of the ulna, previously reported by Severinus (1644), Rognetta (1834), Dupuytren (1839), as well as by others, before being popularized by Darrach in 1912, should not be used in the treatment of simple luxation of the distal radio-ulnar articulation when both of the bones are otherwise normal, because it is destructive, extensive, and unnecessary.

As for the sling operations, he reported that the dislocation is not always prevented, because the slings prevent only lateral separation of the radius and ulna and do not prevent anteroposterior luxation. Further, they limit rotation, and with time, wear definite grooves on the neck of the ulna.

The procedure he presented consists in a six-centimeter, longitudinal incision made over the dorsal aspect of the distal radio-ulnar joint. The extensor digitorum communis and extensor indicis proprius tendons are retracted laterally while the extensor carpi ulnaris and extensor digiti quinti proprius are retracted medially. The dorsal carpal ligament is partially incised. The soft tissues overlying the radio-ulnar joint are incised transversely and are reflected proximally in order to produce a flap to cover the fascia at the completion of the fascial transplant. Six drill holes are placed in the two bones. The holes are three millimeters in size and are only drilled through cancellous bone. The first drill hole is placed in the head of the ulna near the lateral border, just proximal to the cartilaginous rim which covers the distal half of the distal end of the ulna. The second hole is placed in the neck of the ulna, one centimeter proximal to the first hole. Two holes are then placed in the medial border of the radius on a level opposite the two holes in the ulna. Finally, two additional holes are placed farther laterally. Thus, four drill holes are placed in the radius and two in the ulna—the extra two holes being used to gain greater purchase on the fascia in order that it may be sutured under firmer tension away from the articulation rather than directly at the joint where looseness and relaxation can occur.

[10] 525 East 68th Street, New York 21, N. Y.

The fascial strip is removed from the thigh, is started through the most distal and lateral drill hole of the radius, and is brought out through the corresponding medial hole. It is passed across the radio-ulnar joint into the proximal drill hole of the ulna and out through the distal hole of the same bone; then it is passed back across the joint to the most proximal and medial hole in the radius, and out through the corresponding lateral hole. With the forearm held in neutral rotatory position, the fascia is drawn taut and is sutured to itself across the two most lateral holes of the radius. The fascia thus produces an X-shaped ligament, not through the joint, but across the external aspect of the articulation. Lastly, the transverse soft-tissue flap is brought distally across the fascial transplant, the tendons are replaced in their grooves, and the dorsal carpal ligament is sutured.

He emphasized that this new method is offered for the stabilization of luxations of the distal end of the ulna. It makes unnecessary the use of external support, such as splints and wristlets; it is not destructive, as are resections; it does not produce ankylosis, as do the metallic appliances; and it does not allow luxation, as do the fascial slings. The procedure has been found satisfactory in all respects.

DR. DONALD B. SLOCUM [11] in discussion pointed out that an appraisal of a new surgical procedure is based upon indications, technique, and clinical evaluation of end results.

He observed that chronic traumatic subluxations may be classified as (1) the anterior or hypersupination type, (2) the posterior or hyperpronation type, (3) the vertical type, in which there is a decrease in the radial length as a result of excessive resection of the radial head, fracture of the shaft of the radius, fracture of the distal end of the radius, or epiphyseal injury with growth arrest, and (4) the rotatory deviation type caused by malunited fracture.

By description, he felt that this procedure is primarily designed to stabilize against posterior or hyperpronation subluxation of the distal radio-ulnar joint by the re-enforcing of the distal posterior radio-ulnar ligament. Since the joint relationships should approximate the normal following reconstruction, the radius and ulna should be normal with the exception of the styloid process of the ulna which may or may not be fractured. When this situation applies, the next criterion for operation is whether or not the joint is painful or disabling, for many of the less severe subluxations are not. Normal joint relaxation must be differentiated from subluxation by examination of the opposite wrist.

As for the operation itself, the formation of an X-shaped fascial support to re-enforce the distal posterior radio-ulnar ligament appears to be sound. On theoretical grounds, it should be preferred to the circumferential fascial slings which have their principal effectiveness in being used against lateral instability. It should also accommodate to the changes in the length of the radius during pronation and supination. Technically, he felt that the operation itself does not appear to be unduly difficult. He raised the question of the size and strength of the fascial strip. Since this must pass through a drill hole three millimeters in size, it must be quite small. The actual length of the strip removed from the thigh was not stated. He also raised the question of whether this procedure had been used for anterior subluxations and asked what variations in technique had been encountered.

Concerning the clinical evaluation, he stressed that there is no question that restoration of normal painless motion in eight consecutive cases was noteworthy and that it appears that further clinical trial is most certainly indicated.

Dr. Liebolt said in closing that luxation of the radio-ulnar joint is not a common condition. Many patients who have it are well served with conservative treatment, or without treatment. However, there are certain persons who complain that their wrist is weak.

He observed that there are two types of injury: One follows a wrench, sprain, or twist and results in a luxation. Thereafter, it is exceedingly difficult for persons who perform manual labor to continue with their work. The wrist joint may appear to be unaffected and by x-ray the joint appears to be normal. He stressed that their complaints are valid and emphasized that there is such a thing as a weak wrist.

The second type of injury results from fracture of the ulnar styloid process. Many Colles' fractures heal with excellent bony union of the radius, no swelling, and good motion; yet, the patient complains that the wrist is weak. Such patients should be examined for non-union of the ulnar styloid process.

Concerning the type of incision, he said that he had used a longitudinal one which did not cross the crease of the wrist because it was made proximal to the joint. An S-shaped incision is satisfactory.

As for the length of the fascial strips to be taken from the thigh, he thought fifteen to eighteen centimeters is long enough. He conceded that it appears that the drill holes in the bones are not large, but they do admit an aneurysm needle and the fascia can be pulled through with relative ease.

Regarding the length of immobilization, he said he had left the plaster cast on for eight weeks, which is the time needed for ligamentous tissue to heal. The cast extended only to the elbow with the hand in the proper functional position.

He emphasized that the procedure served as well for either an anterior or a posterior luxation. Whether the luxation is forward, backward, or a combination of forward and backward, the ligamentous repair on the dorsal aspect works equally well. This is fortunate as it would be most difficult to perform the repair on the anterior aspect because of the depth of the joint and the multiple anatomical structures to be avoided.

[11] 431 Eugene Medical Center, Eugene, Oregon

Surgical Principles for Reconstruction of Congenital Hand Deformities. DR. ROBERT M. MCCORMACK [12] emphasized that the surgical principles for reconstruction of congenital hand deformities revolve about two primary considerations: (1) the evaluation of hand function and the planning of the reconstruction, and (2) the technical details of reconstruction of the various tissues. The former demand careful surgical judgment in regard to the following factors:

Maximum function possible: The basic aim for maximum function is alignment of the hand in a useful position with one or more opposable digits. This alignment may be attained by splints (including plaster casts) or by surgical procedures on the skin, bones, tendons, or joints.

Tissues available: One is obviously limited in reconstruction by the original condition of the tissues. All available, useful structures should be saved, free to allow maximum growth, and supplemented by local or distant transfer of tissue, if indicated.

Tissues not available: The defect created for the operation must be acceptable to the family, surgeon, and, later, the child. Reconstructive surgery modifies and supplements available parts, but only in a very limited sense does it add any tissue.

Cosmetic improvement: This is secondary to function, but fortunately most procedures for improvement of function concomitantly help in the final appearance.

Timing of reconstruction: The primary indications for surgery during infancy are to liberate parts for maximum growth, free of torsion, and to remove unsightly useless digits. Further surgery can be deferred until the age of five or six, the surgeon always being aware of any possible damage to growth centers and effects of unyielding scar tissues on the rapidly growing hand. To wait too long for reconstruction of the deformed hand is unjust to the child and his family.

It was stressed that an adequate skin cover in surgically correct locations can frequently do more to correct the deformity than any other procedure. Attainment of an adequate skin cover involves many of the principles and techniques of plastic surgery. In the small hands of infants and children a healed surgical incision is approximately the same absolute width as in an adult; yet, in proportion to the size of the finger, it is greater and can easily produce a skin-flexion contracture if it is placed anterior to the mid-lateral line. Thus many techniques for correction of syndactylism fall short of perfection because of such an anterior skin-flexion contracture on at least one finger.

In the treatment of annular grooves, the conventional outlines of a Z-plasty with an angle of 60 degrees are difficult to attain, especially in a deep groove, and frequently give an incomplete correction with residual depression. He had found the following method of Z-plasty to be useful in the treatment of circular contractures.

The contracture and the adjacent tissues are excised for about one half of the circumference, the soft tissues are undermined slightly at the level of the deep fascia, and perpendicular incisions are made. This incision creates two triangular flaps when opened out, which in turn are fitted into similar alternating incisions on the opposite side. That the flaps are kept large with a wide base ensures good healing and contour.

After adequate skin cover has been obtained, one is often disappointed at the persistent malalignment of congenitally deformed parts, particularly when the results are compared with our theories of the "normal" position of function of the hand. This is a manifestation of the fact that practically all congenital hand deformities involve not one but all of the tissues of the hand. Hence correction of skin elements alone rarely completely corrects the deformity. Functionally, however, a congenitally deformed hand which has been relieved of constricting skin elements and excess, useless parts can develop with the child to become an extremely dexterous extremity.

He stressed, with these facts in mind, that it seems logical to be quite conservative in surgical procedures on tendons, bones, and joints in a growing child's hand. In the infant, splinting (including plaster casts) may be effective, but usually for only the more gross deformities at larger joints, and not for the fingers. Tendons from an excess or useless digit can be transferred for added function and partial correction of alignment, but they are relatively ineffective. In the infant, surgical procedures on the bones, other than early separation of fused digits, are usually deferred. At a later age, he thought, the most useful bone surgery in the congenitally deformed hand is arthrodesis and osteotomy to correct gross malalignment. An arthrodesis in the hand combined with adjacent moveable joints can make a very valuable contribution to total function.

A cinefluorographic film of a congenitally cleft hand was shown to illustrate a technique which may prove to be of value in motion studies.

In discussing this paper, DR. ARTHUR J. BARSKY [13] emphasized that it is of the utmost importance that the surgeon present a careful, accurate prognosis, especially when residual disfigurement and dysfunction are to be expected. If this is neglected, keen disappointment may result, for sometimes parents are inclined to expect too much.

The necessity of the family's acceptance of residual deformity and the role that the parents must play in helping the child to make a satisfactory psychological adjustment should be explained. A well adjusted, stable child will use the hand and will develop surprising dexterity, while a maladjusted child will hide the member.

[12] 260 Crittenden Boulevard, Rochester 20, New York

[13] 174 East 72nd Street, New York 21, N. Y.

So far as the time of operation is concerned, unless there is some definite contra-indication such as the possibility of interference or damage to growth centers, his preference is for early operation, especially in cases where delay may prevent proper development of the parts.

In general, he felt that the little patients do quite well. It is true that tiny fingers and hands are difficult to immobilize but it can be done.

He said that while Dr. McCormack uses a curved incision in operating for syndactylism and while he prefers a more angulated one, the main point to be emphasized is that a straight incision should never be used.

Dr. William H. Frackelton [7] felt that, in general, the postponement of correction to an appropriate age is best. One type of deformity he thought worth special mention in this regard—namely, the "clumped" hand with fused distal phalanges. Early separation to prevent torsion deformity is necessary. Attempts by section were ineffective and damaging. Dorrance, in a personal communication, had described for him the use of subcutaneous division of the fusion. Dorrance had considered that motion of the fingers prevented re-union. This had not been a satisfactory procedure in Dr. Frackelton's hands. Skin-grafting of the distal phalangeal portions immediately following separation had been satisfactory. It was done within the first six months or year of life. The separation and grafting in syndactylism was limited to the distal phalangeal portion; it was not done on the total length of the fingers. This procedure he uses for fingers of different potential length, that is, fused little and ring fingers. When bony fusion is disconnected early, torsion and joint deformity are minimized. Completion of the correction of syndactylism is then postponed until the immediately pre-school age.

Within the past few years an attempt has been made to determine the growth pattern in congenital deformities for a given hand. The results are inconclusive. One hundred and five cases have been examined and x-ray films were made at intervals of six months. In general, as one would expect, growth was less in the deformed hand, and the rate was irregular. The disparity in size of the two hands became less with time, but at different rates in different patients.

He noted that the x-ray exposure used in making the cinefluoroscopic film of hand motion shown is the equivalent to that used in taking eight to ten ordinary x-ray films. He was sure that damage to growing epiphyses need not be anticipated from this, but he cautioned that the procedure should be repeated only for limited and infrequent intervals in the growing child. He stressed as a further goal the prevention of additional bone and joint deformities in the growing child. He referred to the work of Phemister, Haas, and Blount which had to do with limiting bone growth by epiphyseal arrest, preferably temporarily. The technical difficulties of these methods limit their use in controlling bone growth in the small parts of the hand. The idea of reversing this and stimulating bone growth is appealing. Perhaps C. Laird Wilson's method of stimulation by the electrolytic action of metallic implants of two different metals placed within the cortex of bone near the epiphysis would be applicable. If growth can be limited to one side of a deformed joint, or made greater on one side than on the other, deforming angulation might be lessened.

*Tendon Transplants in Median-Nerve and Ulnar-Nerve Paralysis**. Dr. Daniel C. Riordan [14] presented observations on the Fowler method of tendon transplantation to restore function to "clawed fingers" resulting from a combined median-nerve and ulnar-nerve paralysis. In addition, he suggested a modification of the Fowler procedure for use in those hands in which the Fowler procedure or the Bunnell multiple sublimis transplant is not applicable. He did not discuss the restoration of opposition to the thumb.

The *main en griffe* deformity represents the end result of muscle imbalance in the hand from paralysis of the intrinsic muscles. Involvement of the median and ulnar nerves results in the same claw hand, regardless of the etiological agents or disease processes. Poliomyelitis, Hansen's disease, syringomyelia, Charcot-Marie-Tooth disease, and traumatic lesions all may result in typical claw-hand. In some of these processes sensation is unaffected and in others it is lost. In traumatic lesions, the nerves should be so repaired that some degree of sensation will return. He emphasized that, in some of the disease processes, loss of sensation is so gradual that the patient unknowingly substitutes sight for lost sensation, and continues to use the hand despite the developing deformity. This latter type of hand readily lends itself to surgical reconstruction. In discussing the cause of the deformity, he pointed out that the principal loss is the flexor component of the interossei and lumbricales on the proximal phalanx, which leaves the long-extensor action on the proximal phalanx unopposed. This causes hyperextension of the metacarpophalangeal joint, increases tension on the flexor profundus and sublimis, and inactivates the pull of the long extensor on the distal two phalanges. Thus, the distal two phalanges go into flexion, the extent depending upon the degree of hyperextension at the metacarpophalangeal joint.

He reviewed, in dealing with functional anatomy, the concepts of Duchenne, Bunnell, and Fowler. Although Duchenne's observations on the results of electrical stimulation of the extensor muscles recorded their true function, Dr. Riordan felt that he drew the wrong conclusion. In his description Duchenne stated that "The distal two phalanges extend on the proximal, and then the proximal phalanx extends on the metacarpals, then the metacarpals extend with the carpus on the forearm". He further stated "The instant the continuing extension reaches a position forming an angle with the forearm [hyperextension] the two distal phalanges flex on the proximal phalanges in proportion to the extension of the hand. Then, irrespective of the strongest contraction of the extensors produced by the most intense current, it is impossible to produce extension of the two distal phalanges, while the proximal phalanges continue to extend." Duchenne then wrongly concluded that the long extensors are only extensors of the proximal phalanges. Duchenne also recorded his observations on the function of the interossei and lumbricales and proved that they flex the proximal phalanges and extend the distal two phalanges. He described their lateral movements.

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[14] 1538 Louisiana Avenue, New Orleans 15, Louisiana

Dr. Riordan emphasized that Bunnell's ingenious work on the function of the interossei and lumbricales brings out that a synergism exists between the intrinsic and extrinsic (long extensor) muscles. Bunnell stated that extension of the distal two phalanges is done by intrinsics in the first half of flexion of the metacarpophalangeal joint, and by the long extensor in the latter half of flexion of this joint. He summed it up by saying, "The gradation between the action of the intrinsic muscles and long extensor is gradual, with the balance of power changing when the proximal joints are at about 45° of flexion. There is, therefore, power of extension of the distal two joints by either the intrinsics or long extensor throughout the range. . . ."

According to Fowler's concept of finger extension, the distal two phalanges are normally extended by both the long extensors and intrinsics synergistically. He pointed out that, if the proximal phalanges are stabilized at or slightly less than 180 degrees, then extension of the distal two phalanges may be done either by the intrinsics alone, or by the long extensors alone, or by both together. This explains why the occasional patient with median-nerve and ulnar-nerve paralysis does not have the typical claw deformity. Thus, the extension of the distal two phalanges is done by the long extensors and it can be demonstrated that the metacarpophalangeal joint capsule is tight and will not allow hyperextension of the proximal phalanx.

In the clinical application of Bunnell's and Fowler's concepts, he stressed that a patient with a radial-nerve paralysis can fully extend the fingers if support is given the proximal phalanges. This function is due to the action of the interossei. In ulnar-nerve paralysis or a combined median-nerve and ulnar-nerve paralysis, full extension of all phalanges can result if the proximal phalanges are blocked at or less than 180 degrees. This function he stated is due to the action of the long extensors on the distal two phalanges. Thus the splinting of radial-nerve paralyses or combined median-nerve and ulnar-nerve paralyses is based on the functional anatomy, and it replaces either the flexor or extensor component on the proximal phalanges.

In the surgical repair of clawed fingers, the Bunnell multiple sublimis transplantation involves the transplanting of multiple slips of sublimis tendons through the lumbrical canals into the aponeurotic expansion and has produced excellent results. In his experience, it has not been satisfactory in the treatment of severe claw deformity or long-standing claw deformity.

Fowler's extensor transplantation entails the use of the extensor indicis proprius, split into two strands, and the two slips of the extensor digiti quinti. He passed each slip through an interosseous space anterior to the transverse metacarpal ligament and inserted it into the aponeurosis. In Dr. Riordan's hands, it was deemed advisable to insert one slip on the radial side of each proximal phalanx in the combined extensor and intrinsic aponeurosis. He felt that success of the transplantations depends upon permanently limiting extension of the proximal phalanges at or slightly less than 180 degrees. Thus, the long extensor can extend the distal two phalanges. Equally important in long-standing cases is the fact that this extensor transplant permanently gives some limitation of wrist flexion, beneficial in preventing a recurrence of the deformity. This procedure he recommended for the treatment of severe claw deformities or long-standing claw deformities.

Occasionally there will be a case of median-nerve and ulnar-nerve paralysis in which there is not sufficient sublimis strength to use the Bunnell sublimis transplant. Also the extensor indicis proprius and extensor digiti quinti may be too weak to use. For such hands he developed an effective tenodesis procedure.

One half of the extensor carpi radialis longus is cut one third of the distance above its insertion and is half stripped distally. It is left attached to the second metacarpal. One half of the extensor carpi ulnaris is treated in the same way. Each of these strands of tendon is split into two slips. The four slips of tendon, two attached to the base of the second metacarpal and two attached to the base of the fifth metacarpal, are then routed through the interosseous space, are brought anterior to the transverse metacarpal ligament, and are inserted into the aponeurosis of the proximal phalanges on the radial side of each finger. Each tendon is placed under sufficient tension to limit mechanically hyperextension of the proximal phalanges at the operating table. That it has been found safer to put the tendons under too much tension rather than not enough was emphasized, for a tenodesis which has been put in loosely will not limit hyperextension and will fail.

In discussion, Dr. Sterling Bunnell [15] stated that he wished to dispel any thought that difference of concepts or of sides in this complicated problem of restoring muscle balance in a finger exists. He said it is just a matter of knowing all the principles and of choosing those methods which are the most suitable.

He emphasized as a fundamental principle that the proximal joint of a normal limb must be stabilized in extension and flexion before the tendons can properly move the distal parts, especially in the base of the finger or in the wrist joint. This is a matter of muscle balance.

Fingers with loose volar capsules cock back in their proximal joints and claw in their distal two. It is well known that the greater the cock-back, the greater is the clawing. If the nerves are injured below their

[15] 516 Sutter Street, San Francisco 2, California

branches to the flexor muscles in the forearm, the clawing is greater for the long flexor muscles are active; and if the flexor muscles are adherent in the forearm, clawing is extreme. In those proximal joints with tight volar capsules, the joints remain straight. They cannot cock back and there is no need for stabilizing them in flexion.

Correction of the cocking back of the clawed finger is a necessity. This cocking back may be so extreme in cases of long-established deformity that structural changes have set in. One of the changes is shortening of the long extensor muscle. Then when the proximal joint is held slightly flexed by tenodesis, there is stronger effect of the long extensor to straighten the finger.

He stressed the fact that normally, the long extensor, because of limited amplitude, extends the proximal joint strongly, the middle joint mildly, and the distal joint weakly and imperfectly. When the attachments are cut, if present in the proximal phalanx, the long extensor is given a longer amplitude to act on the distal two joints. The long extensor works best when the proximal finger joint is flexed from 45 to 90 degrees and works less and less as the proximal finger joints are straightened. In giving an example of shortened amplitude, he said that when he fully flexed the middle finger joints passively, he was powerless to extend the distal joints. There is considerable variation in the degree in which the long extensor can straighten the finger. In the chimpanzee, for instance, there is sufficient excursion of the long extensor to extend all finger joints at once strongly and completely.

He said that Dr. Riordan had developed a good method for obtaining strong tenodesis. The use of split proprius tendon, the slender slips of which are passed in front of the transverse metacarpal ligament, gives a weaker tenodesis. By these methods the tendon has a good angle of approach, namely 35 degrees, the same as that of the lumbrical muscle as it passes in front of the transverse metacarpal ligament to the phalanx.

The tenodesis fails to furnish voluntary flexion to the metacarpophalangeal joint. The sublimis transfer furnishes this. In some people, the long flexor tendons can flex these proximal finger joints, as is seen in some cases of combined median-nerve and ulnar-nerve palsy; but in many others this motion is accomplished mainly by the intrinsic muscles, for the long flexors do not have a sufficient angle of approach.

After the operation, in order to give a positive voluntary flexion to the proximal finger joint, the procedure may be supplemented by a pulley-advancement procedure, so that the long flexor can flex this joint. Capsulectomies may also be needed to allow flexion.

The sublimis transfer is a good basic method and it is sufficient unless the cock back is too strong. It may be supplemented by many other procedures.

He reported various other ways of holding the proximal joints in slight flexion: The Howard bone block may be used; free tendon grafts of the palmaris longus can be woven through cross holes in proximal phalanges, across the front of the joint, over the back of the metacarpal, and can be passed on to each joint in turn, or they may be used as separate grafts to each joint in turn, and each may be anchored to a drill hole across the metacarpal; or arthrodeses of either the proximal or middle finger joints may be necessary for extreme claw-hand. Arthrodesis of either joint will improve the motion of the other joint. Still another method of stabilizing the proximal joint in flexion is the creation of the "intrinsic-plus" condition by means of an escharotic to bring about fibrosis in the interosseus muscle.

He pointed out that just as the normal interosseus muscle needs stabilization of the proximal joint in extension to extend the distal two joints, so also does the long extensor need stabilization of the proximal joint in flexion to extend the distal two joints.

Thus it seems that in patients with straight or moderately cocked proximal joints the sublimis transfer gives good results, but with strong cock back and long-standing deformity the tenodesis or some method of stabilizing the proximal finger joint in slight flexion, perhaps supplemented with a pulley-advancement procedure, is advisable.

Reconstructive Surgery for Shaft Defects of the Ulna in Children. DR. CARMELO C. VITALE [16] stressed that deformities of the forearm in growing children which can be very severe, may be due to trauma, infection, or benign growths, or they may be congenital in origin. Regardless of the cause, if the discrepancy in length between both bones of the forearm becomes too great, an unstable limb results; this will increase with growth.

Proper selection of cases for surgery is important. As a prerequisite, it is essential that there be integrity of the elbow and wrist joints. Regardless of the defects of the radius or ulna, or of both, so long as the elbow and wrist joint structures are adequate, mobile, and stable, surgery can be depended upon to join the fragments into a single satisfactory forearm bone. This will not only retain motion at both joints, but will add stability to the forearm. Furthermore, by joining the proximal end of the ulna with the distal end of the radius into one bone, longitudinal growth is renewed. A better looking and longer forearm is the result.

Two children were presented who had large defects of the distal end of the ulna. One was congenital in origin; the other was due to a large osteochondroma which had required the resection of the lower half of the ulna. In both cases radio-ulnar fusion was done with good cosmetic and functional results. There was, of course, a loss of rotation of the forearm.

[16] 135 Eastern Parkway, Brooklyn 17, New York

The technique employed was to section the radius at the proper level (usually about the middle third) and then, after bluntly opening the interosseus septum, to fix the distal end of the radius to the proximal end of the ulna. In one case, chromic catgut placed through drill holes was used for fixation; in the other, two Vitallium screws were used. Union occurred in both cases. In one of the patients, the head and neck of the radius was removed.

These children have been followed for nine and a half and two and a half years, respectively. The children were each four years of age at the time of surgery. The end results are good as regards function, stability, and cosmetic appearance.

The over-all difference in length of the upper extremity is two inches in one and one and a half inches in the other.

Intramedullary Pinning of the Hand and Fingers. DR. FREDERICK H. VOM SAAL [17] discussed a method of intramedullary-pin fixation in which .062 Kirschner wires, and occasionally .045 wires or needles, had been used. The method has been employed in fractures and osteotomies, repair of non-union, bone-graft fixation, fusion of joints, reposition of amputated finger tips, and splinting for extensor-tendon avulsions. Comminuted fractures of the finger cannot be pinned; moderately comminuted fractures of the metacarpals can be pinned.

Proximal and middle phalanges are pinned by the insertion of the wire into the distal end of the involved phalanx in the middle of the dorsal surface at the joint line. The extensor mechanism is thinnest at this point. The pin must be inserted with the finger flexed to at least 90 degrees; also the pin must be inserted so that it extends almost to the opposite joint line in order to provide adequate fixation in cancellous bone.

When the metacarpals are involved, the pin is inserted through the metacarpal head on its dorsal and radial surface, for the extensor tendons come from the ulnar side of the hand. It was stressed again that, when the pin is inserted, the metacarpophalangeal joint must be flexed to at least 90 degrees. Where the fracture is at the metacarpal base, the pin is inserted into the adjacent carpal bone.

Open reduction greatly simplifies the procedure and is usually used. When metacarpals are involved, pin insertion is then done retrograde from the operative site. The pins are routinely allowed to protrude from the skin and are bent to a right angle in order to prevent migration. A small piece of cotton and collodion prevents extrusion of the pin and allows full use of the hand. The pins are easily removed in from four to seven weeks.

He emphasized that this method provides adequate bone fixation. Its outstanding advantages are the preservation of function and the reduction of cost to both patient and employer. The average patient regains almost full use of the hand in from two to seven days. He can usually return to work. Physical therapy and rehabilitation are unnecessary, for function is preserved.

The excellent results obtained by means of this method of fixation justify the use of this more radical procedure. (For Discussion of Dr. vom Saal's paper, by Dr. Littler [18] and Dr. Metcalf [19], see page 16.)

Problems with Trauma to the Hand. DR. J. EDWARD FLYNN [20] presented two problems in the treatment of trauma to the hand. In one, he considered under what circumstances primary reconstruction and primary closure should be performed and under what circumstances a delayed reconstruction and delayed closure of compound wounds of the hand should be used. In discussing the other problem, he considered how injuries to the flexor digitorum sublimis and profundus tendons should be treated when the site of the injury is within a tight tendon sheath.

Since the advent of antibiotics, there has been no report on the effects of these drugs on the time factor in the management of compound wounds of the hand. Chemotherapy has increased the time factor in the treatment of these wounds. He had used, postoperatively, 40,000 units of penicillin every three hours for at least three days in the treatment of severe injuries. He estimated how much chemotherapy had increased the time factor. His results in the treatment of compound wounds of the hand over a two-year period, on the Hand Service at the Boston City Hospital, were presented.

Compound wounds of the hand were classified according to the types encountered over a two-year period. Incised wounds may be clean or dirty and may or may not involve the tendon sheath; crushed wounds may be clean or dirty and may or may not involve the tendon sheath; and avulsed wounds may be clean or dirty and may or may not involve the tendon sheath. Specific types include involvement with or without the exposure of the bone. In the fingers there may be flexor-surface or extensor-surface involvement; there may be glove avulsion of the fingers or hand with involvement of the volar or dorsal aspects of the fingers or the hand. Late wounds show redness and oedema clinically and on smear show cocci or increased leukocytes. Late wounds may be incised, crushed, or avulsed.

An estimate of the effect which he believes penicillin has on the time factor—that is, the time from injury to operation—in the treatment of compound wounds of the hand was presented.

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[17] 717 North Broadway, Yonkers, New York
[18] 16 East 90th Street, New York 28, N. Y.
[19] 1085 Park Avenue, New York, N. Y.
[20] 475 Commonwealth Avenue, Boston, Massachusetts

The author felt that clean incised wounds which involve tendons outside sheaths can be treated by primary suture within twenty-four hours from the time of injury if there is no inflammation. If the wound involves a tendon within a sheath, primary suture can be done within twelve hours. When dirty incised wounds are being treated, primary suture is indicated within twelve hours if there is no inflammation and if débridement has been complete. When dirty incised wounds involve the tendon, primary suture is indicated within eight hours. If débridement has been incomplete, vital structures should be covered and delayed closure should be done. No primary repair is indicated for tendons when débridement has been incomplete in dirty incised wounds.

In dealing with clean avulsed wounds, the author felt that primary suture can be done within twelve hours if there is no inflammation. When tendons outside sheaths are involved, the incised tendon can be sutured within twelve hours. Repair is not indicated for avulsed tendons at this time. When the incised tendon is within a sheath, it can be sutured within eight hours. Repair is not indicated at this time for avulsed tendons within sheaths. When dirty avulsed wounds are being treated, antibiotic therapy allows primary closure within twelve hours of the time of injury, if there is no inflammation and if débridement has been complete. Lacerated tendons in dirty avulsed wounds in which débridement has been complete can be sutured within six hours—avulsed tendons should not be repaired at this time. When débridement has been incomplete, vital structures should be covered and delayed closure done; primary repair of tendons is not indicated.

In treating clean crushed wounds, he felt primary suture is indicated within twelve hours from the time of injury, if there is no inflammation. When the tendon involved is outside a sheath, the incised tendon can be sutured within twelve hours. Crushed tendons should not be repaired at this time. When the tendon involved is within a sheath, the incised tendon can be repaired within six hours. Crushed tendons should not be repaired at this time. When the crushed wound is dirty and débridement is complete, primary closure can be done within eight hours of the time of injury if there is no inflammation; when debridement has been complete in a dirty crushed wound, incised tendons can be sutured within six hours. Crushed tendons should not be repaired at this time. When débridement has been incomplete in a dirty crushed wound, the vital structures should be covered and delayed closure should be done. No primary repair of tendons in this type of wound is indicated if débridement has been incomplete.

On the Hand Service at the Boston City Hospital, over a two-year period, 484 compound wounds of the hand have been encountered. In two of these postoperative sepsis developed. No gross sepsis occurred.

In the second problem, he considered the treatment of lacerations of both flexor digitorum sublimis and profundus tendons, when the injury is between the distal transverse crease of the palm and the middle of the middle phalanx. He has had the poorest results in repair of flexor tendons in this region where the tendons are enclosed in a narrow firm sheath.

The results, following reconstruction of flexor tendons within a sheath, are classified on the basis of the ability of the patient to bring the injured finger tip to touch the distal transverse crease of the palm on flexion.

An optimum result is considered to have been obtained when flexion at each joint is 90 degrees or the equivalent. On flexion the tip of the finger touches the distal transverse crease of the palm. A fair result is one in which active flexion at each interphalangeal joint is 45 degrees or the equivalent. On active flexion, the tip of the finger can reach to within one and a half inches of the palm. A poor result is one in which active flexion at each interphalangeal joint is less than 45 degrees or the equivalent. On active flexion the tip of the finger does not reach to within one and a half inches of the palm.

In his series, there were eighty-nine patients with injury to both flexor tendons within a tendon sheath. Of these, 16 per cent. were classified *good*, 33 per cent., *fair*, and 51 per cent., *poor*.

Tendons were repaired with the silk technique, the pull-out wire technique, or the suture-at-a-distance technique.

In a series of tendon injuries in which a delayed flexor-tendon-grafting procedure had been done, Boyes had found that in 25 per cent. of the hands in good condition, the patient was able to touch the pulp to the distal palmar crease, and that in 50 per cent. of the hands in good condition the patient was able to bring the pulp of the finger to within one half inch of the distal crease of the palm, postoperatively.

Dr. Flynn believed that primary tendon-grafting should be attempted in properly selected cases. The wound should be clean and incised, with no element of avulsion or crushing. Both sublimis and profundus tendons must be divided between the distal transverse crease of the palm and the distal volar crease of a finger.

A preliminary report was presented on eleven patients with primary tendon-grafting. Six of these were able to touch the pulp of the finger to the distal transverse crease of the palm. Three of these were able to bring the pulp of the finger to within one half inch of touching the palm; and two were not able to bring the pulp of the finger within one and one half inches of the palm on flexion.

He emphasized that the value of the primary tendon-grafting for injury to flexor sublimis and profundus tendons within a sheath cannot be definitely stated until a series of about fifty patients have been treated. (For Discussion of Dr. Flynn's paper by Dr. Sumner L. Koch[21] and Dr. Vinton E. Siler[22], see pages 140 and 171.)

[21] 154 East Erie Street, Chicago 11, Illinois

[22] 1117 Edwards Road, Cincinnati 8, Ohio

Fractures of the Carpal Navicular. DR. CARRUTH J. WAGNER [23] presented a follow-up study of thirty-seven cases of fracture of the carpal navicular with aseptic necrosis of the proximal fragment. Eighteen had been treated by the excision of the proximal fragment, fourteen by prolonged immobilization until revascularization of the proximal fragment had occurred, and five by the excision of the entire navicular. In the group treated by excision of the proximal fragment, all showed a shift in the carpus with an apparent attempt on the part of the capitate to fill the dead space. For ordinary activity there was little significant limitation and few symptoms, but 30 per cent. showed limitation of motion.

In the group treated by prolonged immobilization, revascularization and union occurred in all, and, with the exception of one, all retained a full range of motion; but 50 per cent. complained of mild to moderate discomfort in the wrist after heavy use of the hand.

All five cases in which the entire navicular was excised were considered unsatisfactory.

Two required arthrodesis of the wrist and the others required support when using the wrist under moderate working conditions.

In discussing this paper DR. JAMES K. STACK [24] recalled that Destot, in 1925, published a monograph concerned with his research on the anatomy and function of the carpal bones. He called attention to the fact that the navicular and lunate work as a unit, the scapholunar system, and he compared this system to a moveable meniscus working around the proximal end of the capitate. This proximal end of the capitate is the common center of the movements of the wrist. Dr. Wagner thought that it might be described as a kind of rudder which merely tilts as the satellite bones around it describe a varied pattern of movement. Since the navicular and the lunate are the only two bones which have a common articulation with both the capitate and the radius, they bear the brunt of movements of the wrist and also bear the brunt of violence directed at the heel of the hand.

The long-range follow-up of Dr. Wagner's cases has not yet been made to determine what the eventual changes will be, but he felt that certain shifts will take place in the radial carpal alignment which will predispose such a wrist to future trouble. He did not believe that any substantial segment of the navicular could be removed without causing the remaining fragment to shift toward the radius and the lunate to shift toward the ulna. This would cause interference with the combined motion of these two bones. Certainly, it has been shown many times that, when the entire navicular has been removed, the capitate presses down toward the radius, displaces the lunate toward the ulnar side of the wrist, and traps it there, so that it will become literally a supernumerary bone without function. This will allow the subsequent development of traumatic arthritic changes.

Slides were shown depicting the changes in the alignment of the wrist which lead to disability whenever a substantial portion of the navicular has been removed.

He has had no experience with excision of the proximal pole of the navicular alone, but had the impression that this is not entirely an innocuous procedure and may not be the answer to treatment of non-union and aseptic necrosis of this fragment.

SATURDAY, JANUARY 26, 1952

A clinical session under the presidency of Dr. Michael Mason was held at Northwestern University Medical School. Summaries of the papers presented and a record of the cases shown follow.

Morphological Significance of the Mid-Palmar Fascia. DR. EMANUEL B. KAPLAN [25] pointed out that the mid-palmar fascia is of interest to the hand surgeon because of its involvement in Dupuytren's contracture of the hand, and that it is of interest to the anatomist on account of its close connections with other structures of the hand and its significance in comparative anatomy.

It is considered by a number of anatomists who have studied the hands of reptiles, amphibians, and mammals that the mid-palmar fascia is phylogenetically connected with the short superficial muscles observed especially in the reptilian hand. In the course of evolution, the superficial stratum became connected with the palmaris longus of the forearm; and it can, therefore, be considered to be a superficial flexor of the hand in differentiation from the flexor sublimis and flexor profundus.

A study of the foetal hands and of the hands of the anthropoid apes (gorilla and chimpanzee) and other animals (baboon, rhesus monkey, and tarsius spectrum) shows that, although there is a mid-palmar fascia, the characteristics of this fascia differ from the typical adult human mid-palmar fascia. In foetal hands the formation of the lumbrical canals and the tunnels of the flexor tendons precedes the formation of the mid-palmar fascia. In later stages of embryonic development, the palmar fascia simply adheres to the preformed lumbical canals and flexor tunnels over the metacarpal heads.

It is Dr. Kaplan's contention that the connection of the palmaris longus with the mid-palmar fascia is coincidental. He feels that it is probably not evolved from the short superficial flexors observed in the hands of the reptiles; it is an independent structure connected with the complicated retinacular apparatus of the hand. The septum described previously as separating the mid-palmar space from the thenar space is formed by a septum derived mostly from the ulnar bursa, which extends over the entire crest of the anterior aspect of the third metacarpal and proximally over the carpal bones. The septum connecting the mid-palmar fascia with the crest of the third metacarpal is short and does not extend beyond the distal edge of the ulnar bursa. The study of the relationship of the mid-palmar fascia to the rest of the retinacular apparatus of the hand incidentally led the author to the description of a well organized constant unit consisting of a well developed fat pad of definite length and width, covering the floor of the mid-palmar space for the protection of the branch of the deep ulnar nerve. This pad he named panniculus adiposus palmaris profundus. It can play a certain role in infections of the mid-palmar space as a site of fat necrosis, produced by infection and followed by early accumulation of purulent material in the mid-palmar space.

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[23] U. S. Marine Hospital, Staten Island, New York

[24] 700 North Michigan Boulevard, Chicago 11, Illinois

[25] 1001 Grand Concourse, Bronx 52, New York

It has been observed and reported that the palmaris longus is absent in approximately 12 per cent. of human hands. He stated that the palmar fascia was not observed to be absent in the large number of hands which he dissected; its absence has not been reported in the literature. In the gorilla, although modified, the palmar fascia is always present; however, the palmaris longus is absent, according to the literature, in about 25 per cent. of specimens. On the other hand, in the material dissected by Dr. Kaplan, none of the pretendinous fibers of the mid-palmar fascia were found to consist of muscle tissue. Were it actually a phylogenetic remnant of a superficial flexor, it is doubtful that such a variation would not exist or not be found, at least in rare instances.

A study of changes in the fascia, as observed in Dupuytren's contracture, does not indicate that the contracted fascia resembles in any fashion a superficial flexor muscle. It indicates a widespread affliction involving not only the mid-palmar fascia, but also the other fascial structures of the hand: the natatory ligament, the superficial transverse ligament, the thenar and the hypothenar fasciae.

In discussion, DR. STERLING BUNNELL[15], stated that in Dupuytren's contracture he always checks whether there is a palmaris longus tendon, since it may be absent, just as in other hands. Phylogentically one finds that many animals have three palmaris longus tendons. Man happens to have only one.

He considers the distal half of the palm as having eight septa and seven columns. Tendons should not be joined here because the tendons would adhere. In the proximal portion the junctures will slide.

Closed Special Care of Snapping Fingers. DR. WALTER C. GRAHAM[26] showed a motion picture which dealt with the care of the so-called "trigger finger", a method of surgical intervention to correct the condition in the finger being illustrated. The condition is most frequently seen in the adult between the ages of forty and sixty, although other age groups are not immune. It is quite common to find the condition involving the thumb in the newborn infant, and Engel reported a case in a man over eighty years of age. The etiology is still uncertain, but frequent local multiple trauma to the involved area seems to be the most likely. One author presented three cases which he felt were caused by the patients' holding the hot instruments necessary in their occupations. Anatomically, there is enlargement of the sublimis tendon in the area where it passes beneath the proximal end of the pulley; this may be subject to trauma which produces swelling, causing the tendon to stick or to snap. The stenosing sheaths may be multiple or bilateral, involving any of the digits, including the thumb. From a pathological standpoint, there is either an enlargement of the nodule on the tendon or a contracture of the sheath through which the tendon glides; either condition may produce the constriction. Authors writing about 1900 often attributed the condition to rheumatism, gout, or some other systemic disease; this is unlikely.

The usual method of treatment requires an incision in the palm of the hand which exposes the tendon and the pulleys, and the excision of a portion of the pulley or the opening of the sheath on one or both sides to relieve the constricted area. On occasions the nodule has been partially excised so that the enlarged portion of the tendon will be eliminated. Dr. Graham found that, in the simple type in which other pathological conditions are not suspected, a single anterior longitudinal opening of the pulley is sufficient to relieve the condition. The sheath should be opened through the excursion of the nodule or the enlargement of the tendon which catches in the pulley.

The anatomical dissections and illustrations of the opening were shown in the motion picture, and the safety factor which allows the use of the subcutaneous method was indicated. With a sharp tenotome-type blade, the sheath can be opened longitudinally without the danger of cutting the tendon or damage to the adjacent nerves and blood vessels. The operation is carried out under local anaesthesia; after the area has been localized by palpation, novocain is injected into it and into the tendon sheath. Usually a single longitudinal sweep of the knife from the area of palpation of the nodule distally, directly anterior to the tendon, will relieve the constriction by opening the pulley. The patient is then instructed to move the finger; if it does not move freely, the sheath may be opened a little further distally. This whole procedure is carried out through a very tiny puncture wound, and for this reason suturing is unnecessary. The closed method has the distinct advantage that the wound does not require suturing, and the patient can return to his former work on the day of the operative procedure. Patients have lost no time from their work and there has been no injury to the nerve, tendons, or blood vessels.

He would not advocate the use of this method in the treatment of deQuervain's disease, stenosing tenosynovitis, or "snapping" of the thumb.

[26] 1421 State Street, Santa Barbara, California

In discussion, Dr. Graham was asked the age of the patients treated. He replied that they were all over thirty-five and under sixty. He believes that is the usual age group for the condition except for the newborn in whom the thumb is practically always involved. He has not seen any other fingers involved in the newborn except the little finger.

In answer to the question of the manner in which the blade was fixed, he said that a No. 15 blade is used after the cutting surface, with the exception of the distal two millimeters, had been completely dulled. This has been as satisfactory as fascial knives because of the sharpness. In regard to recurrences, no patient has returned who has been treated by this method. Follow-up has been as long as three years. No case was reported which had been followed less than six months.

The question of terminology was raised in regard to stenosis. It was stated that the condition seems to be a relative stenosis in that the annular ligament is tight and prevents the passage of a fusiform swelling. For some reason the relation to trauma has become acknowledged as a probable cause rather than a true primary narrowing of the annular ligament. In the pre-atomic age the questioner had occasion to inspect the tendon rather carefully. In several of the cases a degenerating portion of the tendon and a small cyst were found; in some cases there was a small area which appeared to have granulations which seemed to settle in a portion of the tendon. That is comparable to the supraspinatus degeneration. He would be inclined to focus attention on the tendon primarily, but also on the sheath. If the operation is done subcutaneously, the pathological condition will never be seen.

Dr. Graham stated that he had opened the palm and explored the tendon and the sheath on many occasions. The nodules mentioned by Dr. Stephenson had been subjected to biopsy and the pathological findings were not remarkable. The tendon may become enlarged or the sheath may become contracted because of fibrosis. The main problem is to relieve the tightness so that the tendon will glide freely.

The method was thought to be excellent technically, but it was hoped Dr. Graham would not become too enthusiastic in showing it around the country, because some people not familiar with the anatomy might attempt this operation.

Dr. Boyes felt the picture should be shown more widely. One patient who had this operation done by someone else required a repair of the digital nerve with a disability period which extended over four months. He thinks there is a definite danger in it, but he is in favor of showing the picture widely.

Dr. Graham feels that this method should not be publicized to the profession but should be confined to this distinguished group who know the anatomy and the possibilities, and in whose hands it is a perfectly safe procedure. Any operation which is advocated is not advocated for indiscriminate use but only for the use of those with the experience to carry it out.

*Problems of Postoperative Position and Motion in Surgery of the Hand.** DR. JULIAN M. BRUNER[27] pointed out that a proper postoperative position and a sound schedule of postoperative motion may make all the difference between success and failure in surgery of the hand. On completion of repair of a tendon or a nerve in the forearm or hand, the surgeon is confronted with questions relative to specific postoperative position, to the best method of maintaining the position, to the expected duration of the position, to motion in uninjured fingers or thumb, to the time of onset of motion in injured fingers, and to the time at which the restraining splint may be safely discarded.

The position of rest as described by Wood Jones and the position of function as detailed by Bunnell were discussed. The position of function is usually indicated after plastic procedures on the hand, after burns, in infections, and after certain compound injuries. Failure to place the hand in an accurate position of function is a common mistake; an adducted thumb and fully extended metacarpophalangeal joints are the errors most commonly seen.

The position of flexion is indicated after flexor-tendon repair; the wrist should usually be in only moderate flexion. Overlong restraint of the wrist in the acutely flexed position is dangerous and may lead to permanent loss of dorsiflexion range of the wrist joint. A case in point was reported.

The position of extension is indicated after extensor-tendon repair. Although full extension of the metacarpophalangeal joints is necessary, this must not be maintained too long. A case was cited in which permanent loss of the ability to close the hand resulted from prolonged splinting of the fingers in full extension after the repair of an extensor tendon.

Immobilization of the hand for even short periods of time results in more or less stiffness which may be temporary or permanent. Immobility is unnatural to the hand, and the hand reacts unfavorably to it.

The question of motion after tendon suture is still controversial. Various views were presented as to the desirability of early motion after tendon repair or tendon-grafting. Any but very gentle movements of small amplitude are dangerous during the first fortnight; complete rest is probably safer.

The reason for joint stiffness after immobilization is not the immobilization itself, but the cessation of functional activity around the joint, and especially the stagnation of tissue fluids. Measures to promote the return of circulation in the hand were described.

* Paper to be published in the April issue of *The Journal of Bone and Joint Surgery.*

[27] 1005 Bankers Trust Building, Des Moines 9, Iowa

"Perpetual motion" should be the rule in the hand: Uninjured portions of the hand should, if possible, be kept moving; injured portions should be mobilized at the earliest possible moment consistent with the healing of repaired structures.

In the discussion, Dr. Condict Cutler, Jr.[28] emphasized one feature which he felt is basic and fundamental—that is, in postoperative splinting after a tendon injury, the splinting should be applied on the side opposite to the side in which the repair was done, in order to avoid an opposed contraction of the muscles against the firm splint, which in itself might very easily cause injury. A splint on the opposite side, whether it is a dorsal splint or a volar splint, does not present a firm opposition against which the repaired tendon might exert its force.

He profoundly disapproved of vigorous physiotherapeutic procedures in dealing with the postoperative hand conditions but approved and taught that directed active use of the muscles is by all odds the best means of restoring function in damaged hands. He hoped that a review of the restoration of joint and muscle function by corrective splints might soon be presented.

Hilgenfeldt's Reconstruction of the Thumb. Dr. Hans May [29], before discussing the Hilgenfeldt method of thumb replacement, stressed a few of the functional and anatomical peculiarities of the hand.

The human hand can be used for fine and for rough work. When fine work is done, the pinch grasp is used—that is, with the tip of the thumb in opposition with the tips of the index finger and the third finger. When the pinch grasp is made, it is not absolutely necessary that the thumb have full motility and full length. Neither is full motility of the interphalangeal joints of the second and third fingers required, provided that the thumb and the interphalangeal joints have been ankylosed in the position of function and that the metacarpophalangeal joints of the index and the third fingers are mobile.

When rough work is done, the broad grasp is used, whereby the second to fifth fingers are flexed around an object, pressing it to the palm. The thumb comes into action for heavier objects and grasps them from the opposite direction. For this grasp, the full length of the thumb is not required.

The third type is the thumb grasp in which the volar side of the thumb is pressed against the radial surface of the phalanges of the flexed index finger. For this, the full length of the thumb is not required.

If the thumb is absent and is to be replaced, the new thumb should have normal sensitivity. Hence, the use of composite flaps to reconstruct the thumb should be the last resort. The thumb is best replaced with another finger. If this is the case, the volar digital arteries and nerves of the finger to be transposed should be intact. The dorsal vessels and nerves, however, are not important. Tactile and thermal sensitivity alone do not appear sufficient to give the patient a feeling of having a new thumb. The patients seem to localize the sensorial conception of touch in the transposed finger at its former site. Something else seems to be required to restore the normal sensorial conception of having a thumb. In the first case, as reported by Hilgenfeldt, the patient in whom he replaced the missing thumb with the third finger sensed the new thumb as a thumb only after the flexor tendon of the former thumb had been attached to the flexor tendons of the transferred third finger.

Hilgenfeldt's operation is a modification of the Luksch method. Whenever possible, he used the third finger for substitution. A volar-skin bridge was formed, one centimeter wide, which reached from the base of the third finger to the longitudinal crease of the palm. This pedicle contained the digital arteries, veins, and nerves. The branches to the index and fourth fingers were tied and were severed. From a dorsal incision just distal to the third metacarpophalangeal joint the third finger was disarticulated; the volar structures which also include the flexor tendons were not incised. An incision was then made from the base of the pedicle to the scar over the stump of the first metacarpal. If the flexor pollicis longus could be found, the operation was carried out in one stage. The first phalanx of the third finger was shortened to proper proportions and was fastened upon the stump of the first metacarpal by dove-tailing. The flexor pollicis longus was sutured to the flexor profundus of the third finger and the extensor tendon of the third finger was sutured to the extensor tendons of the thumb. This was followed by immobilization of six weeks. If the flexor pollicis longus tendon could not be found, a second stage was performed six weeks after the first operation. In this operation the flexor pollicis longus was sutured to the flexor profundus of the third finger from a transverse incision in the wrist.

As already mentioned, Hilgenfeldt preferred to transfer the third finger. He, however, did not insist on the third finger. If the second, third, or fourth fingers were damaged, he advised the use of the damaged finger. If, however, all fingers were normal, he preferred the use of the third finger. He stated that the index finger has a greater range of motion with respect to abduction and adduction than has the third finger. Hence, it is more important; and, for this reason, it should be left intact.

Dr. Sterling Bunnell pointed out that he had, during the last War, abundant opportunity to see a lot of thumb reconstructions and to participate in many. This experience taught certain principles. One was that a short thumb is a good thumb. Many of the thumbs reconstructed by pedicled tube grafts had the disadvantage that, although they could distinguish touch and pin prick, they did not have stereognosis. It became apparent to him that the thumb must be placed properly so the fingers can work against it and past it. The fingers move sideways one and a half inches and so can do both.

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[28] 620 Park Avenue, New York, N. Y.

[29] 255 South 17th Street, Philadelphia 3, Pennsylvania

He stressed that a thumb should be very carefully positioned for function, so the fingers can work against it.

He did not agree with mutilating the other hand by taking the third finger. He had discarded the use of the foot.

In 1928, a patient without any metacarpal came to him for a thumb reconstruction. He attempted to give this patient full motion and sensation by building a new thumb with both those features. The metacarpal of the index finger with the proximal phalanx was transferred and the trapezium was lashed to it by means of a tendon graft. All the tendons, extensors, and flexors were connected, and all the muscles of the thenar eminence were joined, so that the thumb had eight muscles to move it. The nerves were never disconnected, but they were split down to the base of the palm. The nerves were retained with the blood vessels and were kept intact. That man had good motion and normal sensation. He was a carpenter.

Since that time, Dr. Bunnell has been urging operators always to give sensation and motion to the reconstructed thumb, for both are necessary for a good thumb. The gorilla has a fine thumb. The gibbon has a small thumb and does not use it in his acrobatics, at which he is so skillful. The chimpanzee has a fairly good thumb, but he has motion by tenodesis only. Many other animals have opposing digits, such as the woodpecker, cuckoo, owl, and African chameleon, but these have no close relationship to thumbs.

Dr. Walter C. Graham felt that reconstruction of the thumb by moving the index finger is superior. If the index finger is used, the metacarpophalangeal joint is utilized; it is better than the interphalangeal joint to act as the thumb joint. It is also desirable that the index finger be reduced to a two-joint thumb; and, if the distal phalanx is amputated, a larger, broader opposing surface can be formed. He prefers to use a damaged index finger rather than to carry out the more mutilating operation.

Dr. May, in closing, emphasized that Hilgenfeldt preferred the transfer of the third finger over the index finger, because of the latter's wider range of mobility (abduction and adduction). Hence the index finger should be left in place. If another finger is damaged, he prefers that the damaged finger be transferred.

Prevention of Postoperative Hematoma in Surgery of the Hand. The Use of the "Compression Suture". **Dr. Radford C. Tanzer** [30] emphasized that two factors are of outstanding importance in the prevention of postoperative hematoma in surgery of the hand—namely, complete hemostasis and the elimination of dead space. Several conventional methods of elimination of dead space were discussed.

In hands in which depressions or pockets make the coaptation of tissue layers difficult, as in closure after the resection of the palmar fascia or in the application of pedicle flaps to depressed areas in the hand, a method in which the "compression suture" is used has proved effective. The method consists in the introduction of one or more transfixion mattress sutures which are carried through the dressing, skin flap, or free graft and underlying base, emerge from the opposite skin surface (as, for example, in the transfixion of the hand), and are tied over buttons in order to pull the flap or graft snugly into position. The whole is then enclosed in a bulky fluffed gauze dressing encased in an elastic bandage. The regions which have proved most amenable to the use of the "compression suture" are the ear, cheek, lips, anterior axilla, scrotum, and hand. The essential requirement is a second skin or mucous membrance surface paralleling the incised surface, on which countertraction may be obtained. Several illustrative cases were presented, showing the use of the "compression suture" in surgery of the hand.

Presentation of Cases

Dr. Michael L. Mason [31] presented three cases of tumor of the hand.

The first was a girl, eleven years old in 1950, who came to him because of a swelling in the left palm, of six years' duration. Previously, some type of operation had been carried out in the palm; but the swelling had persisted and it had become larger. On October 18, 1950, Dr. Mason opened the palm and explored up into the forearm. He found a very extensive neuroma of the median nerve, extending from the lower third of the forearm down into the palm and involving all of the terminal branches of the median nerve. He made several longitudinal incisions into the surface of the tumor, hoping to be able to save some fibers of the median nerve. It soon became obvious, however, that it was not possible to do so. After informing the parents of the situation, he decided to excise the entire nerve. The patient made an uneventful recovery from the operation.

There is absence of sensation over the median-nerve distribution on the palm and fingers. However, opposition and rotation of the thumb are intact. It is well known that in an occasional instance the ulnar nerve innervates the thenar muscles, and such must be the situation here, since the girl has excellent use of the thumb.

The second patient had a history of swelling of the thenar eminence of three years' duration. Nine months previously he had had a tumor excised from the thenar eminence of the left hand. He had had no trouble for a few months, but six months after the operation the tumor recurred. When he was operated upon

[30] Hitchcock Clinic, Hanover, New Hampshire
[31] 154 East Erie Street, Chicago 11, Illinois

a fusiform mass was found, involving the median nerve. This man showed complete anaesthesia over the median-nerve distribution, but he was not so fortunate as the other patient in that he did not show any rotation of the thumb. To compensate for the lack of rotation and opposition, the palmaris longus was transferred across the palm and was attached to the proximal end of the dorsal surface of the proximal phalanx of the thumb. The operation was done on May 25, 1951, and has been quite successful. When the hand and forearm were re-opened last September to place a nerve graft, it was found, when the operators got down into the thumb and into the base of the fingers, that the removal of the neuroma had entailed excision of the digital nerves so far distally that it was impossible to isolate anything in the way of distal stumps. Dr. Mason felt that an attempt at nerve-grafting was not feasible.

Dr. Mason was asked if there was anything characteristic in the early clinical history of these two patients, to which he replied, "No".

Dr. E. B. Kaplan asked him if there was any neurofibromatosis elsewhere.

Dr. Mason said in reply that in the second patient there was. Several months ago he had been operated upon for an inguinal hernia, and his surgeon reported that he had found a neuroma on one of the nerves in the inguinal canal.

The third patient had a rather rare type of epithelioma of the palm. He was admitted to the hospital on March 13, 1947, with the history that two and one-half years previously he had run a sliver of wood into the palm of the hand. Six months after the sliver had been removed, a little tumor developed at the site of the injury. One year later an ulcer developed at the site of the tumor. On March 15, 1947, the tumor was excised generously, and a skin graft was placed over the defect. However, microscopic examination of this mass showed it to be a sweat-gland epithelioma. The patient was then subjected to amputation of the ulnar half of the hand, through the bases of the metacarpals of the third, fourth, and fifth fingers. There was no evidence of tumor in the tissue thus removed. Recovery was uneventful. In August 1948, the patient noticed some enlargement of the left axilla. A few months later he came in for examination, and enlarged axillary nodes were found. An extensive axillary dissection was therefore carried out and metastases were found. Roentgenograms of the chest were negative and the patient has remained well. This is a rare type of palmar tumor,—most carcinomata of the palm are squamous-cell carcinomata.

Dr. John Bell[32] presented two cases of metastatic tumors of the hand. He stated by way of introduction that metastases of malignant tumors to the hand are very rare. There have been very few reported in the literature. Copeland studied a series of 334 metastatic lesions of the bone and found only one case involving the hand. Pack had a series of 171 malignant tumors; two involved the hand. Dr. Bell found in a review of the literature an incidence of fourteen cases in which the hand was involved. Eight patients had carcinoma of the lung.

The first patient, a man aged forty-eight, was admitted to Passavant Hospital in August 1950. It was found that he had a far advanced bronchogenic carcinoma. He was discharged without treatment. He was re-admitted on September 12, 1950, complaining of pain in the thumb; the Surgical Fellow made a diagnosis of felon. He was operated upon, and no purulent material was found. No preoperative roentgenogram had been made; however, following incision, a roentgenogram was made which showed almost complete destruction of the distal phalanx of the thumb.

The pathological picture was shown on a slide. The patient expired and multiple metastases throughout the body were reported at autopsy. Incidentally, he had another bone metastasis to the proximal phalanx of the left great toe.

The second patient was seen by Dr. Mason in 1935. He was fifty-six years old. In January 1935, he had had an orchidectomy for a chorionepithelioma of the testes. Following this he had had x-ray therapy. He seemingly got along well until April 1, 1935, when he was admitted to the hospital complaining of hematemesis and weakness. During his stay in the hospital, it was noted that he had a small discoloration on the nail bed of the right middle finger. Upon questioning, he stated that this had appeared three weeks previously but had grown progressively larger. When the base of the nail was lifted, a melanotic-appearing tumor mass was revealed. The patient deteriorated rapidly and expired within two weeks. A slide showed a pathological section of the metastatic chorionepithelioma of the finger.

It was reported that of the eight cases of carcinoma of the lung with metastases to the hand which were found in the literature, it was interesting to note that the distal phalanx had been involved in six of the patients. One patient had had three distal phalanges involved, so that it made a total of eight. All the lesions reported in the literature had been osteolytic lesions. It was also interesting to note that in three of the patients, the onset of pulmonary symptoms had occurred after their complaints about the hand lesions. Practically all the cases had been diagnosed as chronic felon with osteomyelitis or paronychia.

Of the other cases in the literature in which there were metastases to the hand, there was one from the thyroid gland, one from the breast, one from a lymphosarcoma, one from carcinoma of the uterus, and one from carcinoma of the bladder.

The question was raised whether these were squamous-cell carcinomata or adenocarcinomata of the lung. Dr. Bell said they were squamous-cell carcinomata.

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[32] Northwestern University Medical School, Chicago 11, Illinois

Dr. Harvey S. Allen [6] presented three cases in which immediate repair of flexor tendons had been done.

The first patient, a boy, had had a soda glass bottle explode in his hand on July 13, 1951. He had been brought to the hospital immediately and repair had been done. The laceration extended across the proximal joint on the volar aspect just between the bifurcation of the tendons. It was drawn down and was united with two mattress sutures. The hand was then splinted.

The second patient was a woman with a similar story. It had been recognized immediately that there was an injury to the tendon and she had been transferred to the hospital. The laceration had been opposite the phalangeal joint. An incision was made across the palm; the profundus tendon was brought through and was united with fine white silk.

The third patient had had an injury across the volar aspect of the fingers. The lesion had been recognized immediately. Under general anaesthetic, it was found that the profundus tendon had only retracted to the level of the bifurcation; it was therefore possible to elevate it. Repair was done in the same manner as that in the previous case with No. 50 white silk. The accident happened in October 1951, and today he has good strength in his hand.

Dr. Harvey S. Allen also presented two rather unusual cases of burns from hot plastic. Such injuries are new. The plastic had been heated to about 425 degrees and then had been injected into a mold under pressure of 400 pounds. The first patient, a woman, had had a burn in the palm of her hand while working with the hot plastic. There had been necrosis of the tendons. A complete débridement was done, and one week later a pedicle flap was made. At a later date the flap will be trimmed and the extensor tendons will be repaired.

The second patient had come in with a large swelling extending through necrotic muscle tissue. There had been loss of the interossei. It seemed very like an ulnar-nerve lesion, because the dorsal interosseus had been burned away. Skin-grafting was done. Since he had had a partial division of the flexor tendon of the index finger, he cannot flex the fingers.

Mr. Harold Bolton [33] presented three cases in which there had been repair of tendon injuries by grafts and tenolysis.

In February 1951, the first patient, a man, had received a crushing injury to the hand from a four and one-half ton weight. He had sustained a transverse wound of the palm with extension to two fingers and fractures of the metacarpals and phalanges. The initial care had been in another hospital, where the wounds had been cleansed and the fractures had been treated. When seen in October 1951, he had complained of a disagreeable sensation in the fingers and an inability to flex the fingers into the palm, especially the middle and ring fingers. At operation on October 10, 1951, the old scar in the palm was excised and the digital nerves were identified. All were found to be intact but were bound down in the scar tissue. They were freed. The flexor tendons were then freed in the palm. Through a small incision in the fingers, the sublimis tendons were found and were excised; this permitted a much greater degree of flexion. It was possible passively at operation to bring the fingers down almost all the way into the palm. The hand was immobilized for a short period to permit healing of the wound, and then motion was started. He regained satisfactory motion of his fingers.

The second patient, a man, aged twenty-three, had a somewhat different problem. In June 1951, he had cut his right index finger over the middle phalanx. Immediate repair had been undertaken elsewhere, but unfortunately a short time after operation the hand had been passively extended. From that time on he had not regained profundus control. When seen in September 1951, he had passive motion of the fingers and sublimis action but no action of the profundus tendon. On September 26, 1951, a tendon graft was placed in the finger. It was noted that the sublimis tendon was completely intact; so it was not removed. The graft was attached distally to the distal phalanx by the method described by Dr. Allen and proximally by inserting the graft into a buttonhole in the profundus stump in the palm. The patient has an excellent range of motion, some four months after operation.

The third patient, a girl, was seen in 1950, with the history that six years previously the left index finger had been cut on glass. She had been thereafter unable to flex the distal joint. When the patient was examined, a striking feature was the marked atrophy of the terminal phalanx. There was no nerve lesion. The finger was atrophic and undeveloped, associated in some manner with inability to flex the terminal joint. A tendon graft was placed on July 12, 1951. The graft was taken from the dorsum of the foot. It was done with the hope that, by restoring function, the finger might also be brought to a more normal appearance. After operation the finger showed a much more normal appearance, although some fibrotic change was present, and there was a very excellent range of motion.

Dr. Sumner L. Koch [21] presented a case in which repair of tendon injuries had been done by means of grafts and tenolysis. This patient came to him some time after an injury to the thumb, with division of the flexor pollicis longus. The immediate operation had been followed by infection. When she came to him there was still residual infection and a suture protruding from the wound. After its removal, he waited six weeks for the inflammatory reaction to subside. Early in August 1951, a tendon graft was placed. Because she was ill she had not been using the hand as much as he would wish, but an excellent result is probable.

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[33] 9 Woodthorpe, Oxford Place, Manchester 14, England

News Notes

The next Annual Meeting of **The American Orthopaedic Association** will be held at The Homestead, Hot Springs, Virginia, June 28 to July 1, 1953.

The Part II examinations of **The American Board of Orthopaedic Surgery** will be held on January 21, 22, and 23 in Chicago, Illinois. Further information may be obtained from the Secretary, Dr. Harold A. Sofield, 122 South Michigan Avenue, Chicago.

The Twentieth Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, Illinois, from January 24 through January 29, 1953. An entirely new program format has been adopted, allowing for expansion of the Instructional Courses, the Scientific Program, and the Audio-Visual Program.

The Scientific Exhibits, planned by Dr. Lyman Smith, and the Technical Exhibits, under the chairmanship of Dr. Carlo Scuderi, will be open for inspection from 8:30 a.m. to 6:00 p.m. Saturday through Wednesday and from 8:30 a.m. to 1:00 p.m. on Thursday.

The program of Instructional Courses, arranged under the chairmanship of Dr. Charles N. Pease, will be presented every morning, Sunday, January 25, through Wednesday, January 28, and will include new courses and repeat courses which have proved to be especially valuable and popular in previous years. Dr. H. Herman Young, Chairman of the Program Committee, has chosen a comprehensive group of scientific papers to be presented daily, Sunday through Thursday. Films selected by the Committee on Audio-Visual Education, under the Chairman, Dr. L. Ramsay Straub, will be shown Saturday, Sunday, Tuesday, and Wednesday afternoons.

The Instructional Course dinner, to be given on Monday evening, January 26 will feature the popular "Information Please" panel of experts. Tuesday evening, January 27, has again been set aside for dinner meetings of the various alumni groups.

The annual banquet and dance will be held in the Grand Ballroom on Wednesday evening.

Induction of the new members will take place on Sunday, January 25, at 1:30 p.m.

Any request for information regarding the 1953 meeting should be directed to the office of the Secretary, Dr. John R. Norcross, The American Academy of Orthopaedic Surgeons, 122 South Michigan Avenue, Chicago 3, Illinois.

The Eighth Annual Meeting of the **American Society for Surgery of the Hand** will be held at the Palmer House, Chicago, Illinois, on Friday, January 23, 1953. The preliminary program includes the following papers:

Unusual Tumors of the Upper Extremity.
  Vinton E. Siler, M.D., Cincinnati, Ohio.
    Discussors: Darrel T. Shaw, M.D., Cleveland, Ohio;
      Lot D. Howard, Jr., M.D., San Francisco, California.
Cutaneous and Subcutaneous Beryllium Granulomata of the Hand.
  J. Edward Flynn, M.D., Boston, Massachusetts.
    Discussor: Harvey S. Allen, M.D., Chicago, Illinois.
Anatomy and Function of the Intrinsic Mechanism of the Hand.
  Don L. Eyler, M.D., Nashville, Tennessee (by invitation).
Intrinsic Contracture of the Hand and Its Surgical Treatment.
  E. Crampton Harris, M.D. (by invitation);
  Daniel C. Riordan, M.D., New Orleans, Louisiana.
    Discussors: S. Benjamin Fowler, M.D., Nashville, Tennessee;
      J. William Littler, M.D., New York, N. Y.;
      Sterling Bunnell, M.D., San Francisco, California.
Corn-Picker Hands.
  Frederick S. Webster, M.D., Lincoln, Nebraska (by invitation).
    Discussors: Julian M. Bruner, M.D., Des Moines, Iowa;
      Walter C. Graham, M.D., Santa Barbara, California.

Mangle Burns and Severe Wringer Injuries in Children.
Joseph L. Posch, M.D., Detroit, Michigan.
Discussors: George S. Phalen, M.D., Cleveland, Ohio;
S. M. Dupertuis, M.D., Pittsburgh, Pennsylvania.
Compound F (Hydrocortone) in Experimental Tendon Repair.
Richard I. Gonzalez, M.D., San Mateo, California (by invitation).
The Effect of Cortisone on the Healing of Tendons in Rabbits.
Gordon Grant, M.D., Victoria, British Columbia, Canada.
The Use of Compound F (Hydrocortone) in Operative and Non-Operative Conditions of the Hand.
Lot D. Howard, Jr., M.D.; Sterling Bunnell, M.D.; and Donald R. Pratt, M.D., San Francisco, California.
Discussor: Gordon Grant, M.D., Victoria, British Columbia, Canada.
Osteoid Osteoma in the Hand.
Robert E. Carroll, M.D., New York, N. Y. (by invitation).
Discussors: Michael L. Mason, M.D., Chicago, Illinois;
Harold B. Boyd, M.D., Memphis, Tennessee.
Congenital Arteriovenous Fistulae of the Hand.
Raymond M. Curtis, M.D., Baltimore, Maryland.
Discussors: George V. Webster, M.D., Pasadena, California;
Thomas W. Stevenson, M.D., New York, N. Y.

At the Annual Meeting of the **American Academy for Cerebral Palsy,** held in Durham, North Carolina, October 2 to 4, the following officers were elected:
President: Arnold Gesell, M.D.
President-Elect: Meyer A. Perlstein, M.D.
Secretary-Treasurer: Harry E. Barnett, M.D.

The Annual Meeting of the **Asociación Argentina de Cirurgía** (Argentine Surgical Society) was held at Buenos Aires, October 5 to 9, 1952, and was attended by many corresponding members.

The program presented was full of interest. One of the subjects was "Treatment of the injuries of the hand". The two official reports were made by Dr. T. Gebauer of Santiago, Chile, and by Dr. Jorge E. Valls, of Buenos Aires.

Dr. R. Guy Pulvertaft, of Derby, England, by special invitation attended the meeting and delivered lectures on "Treatment of stiff hand", "Injuries of the hand", and "Open wounds of the hand". Dr. Pulvertaft also gave a brief course on hand surgery, which was attended by a group of Argentine surgeons.

The first **Inter-American Session of the American College of Surgeons,** to be held in São Paulo, Brazil, February 9 to 12, will offer a combination of excellent scientific meetings of wide variety as well as enjoyable vacation prospects. The Committee on Arrangements is headed by Dr. Benedicto Montenegro, Honorary Chairman, Dr. Moacyr E. Alvaro, Chairman, and Dr. E. J. Zerbini, Secretary.

Information on attendance at this session may be obtained by writing the American College of Surgeons, attention of Dr. H. Prather Saunders, Associate Director, 40 East Erie Street, Chicago 11, Illinois.

Psychological Problems of Cerebral Palsy, recently published by the **National Society for Crippled Children and Adults,** includes the proceedings of the first symposium ever held to consider exclusively the psychological aspects of cerebral palsy. The booklet brings together the important papers of outstanding psychologists presented at that meeting, which was held in Chicago under the joint sponsorship of the Division of School Psychologists of the American Psychological Association and the National Society.

Copies of *Psychological Problems of Cerebral Palsy* can be purchased at $1.25 each from the National Society for Crippled Children and Adults, 11 South La Salle Street, Chicago 3, Illinois.

The Resident Education Committee of the **Newington Home and Hospital for Crippled Children** announce the availability of a one-year approved residency in Children's Orthopaedics, in July 1953. This appointment is an annual one. Application should be made to Burr H. Curtis, M.D., Newington 11, Connecticut.

The Thirty-fifth Annual Meeting of the **Orthopedic Appliance and Limb Manufacturers Association** was held in connection with the Fourth Annual Meeting of the American Board for Certification, in Washington, D. C. on October 12 to 16. Dr. Clinton Compere of Chicago was chosen Vice-President of the Board for Certification, succeeding Dr. Atha Thomas of Denver who retired. Dr. Thomas received the following citation:

> "To Atha Thomas, M.D., founder and Vice-President of the American Board; warm and discerning friend of the orthopaedic and prosthetic appliance profession; trail-blazer in the building of effective cooperation between the surgeon and the certification program; his wise counsel has been invaluable in the deliberations of this Board."

Dr. T. Campbell Thompson of New York was also made a member of the Board, as well as Mr. M. J. Benjamin of Los Angeles and Mr. Lucius Trautman of Minneapolis.

Orthopaedic surgeons can hardly fail to be interested in the review of the work, in its first five years, of the **Sarah Mellon Scaife Foundation's** Multiple Fellowship on Orthopaedic Appliances by George H. Young, Ph.D., Director of Research, Mellon Institute, Pittsburgh, Pennsylvania. This straightforward statement of the work of Mellon Institute scientists in the field of orthopaedic appliances, with the financial backing of the Sarah Mellon Scaife Foundation, should be familiar to all who are interested in technological advances in orthopaedic appliances of every description. The report is available without charge. Requests for Dr. Young's "The Orthopaedic Appliances Program at Mellon Institute—The First Five Years" should be addressed to Mellon Institute, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.

ASSOCIAÇÃO DE ASSISTÊNCIA À CRIANÇA DEFEITUOSA

In 1950, taking advantage of the opportunity offered by the gathering in São Paulo of orthopaedic surgeons from every part of Brazil for the Ninth Brazilian Congress of Orthopaedics and Traumatology, a group of men under the leadership of Dr. Renato da Costa Bomfim launched the first crippled children's association in Brazil, the Associação de Assistência à Criança Defeituosa. This work was supported by a group of interested prominent people. On August 3, 1950, the first general assembly of the new society was held for the purpose of discussing the constitution and proposing by-laws. Present at this meeting were leaders of commerce and industry as well as outstanding professional men. The University of Brazil and the Federal Department of Health were represented; the medical associations were represented in the person of the chairman, Dr. Jairo Ramos, President of the Associação Paulista de Medicina. Dr. Henry Meyerding, a guest of the Congress, was present at this meeting and represented North American Orthopaedic Surgery.

At this time by-laws were adopted and a board of directors and a council for the Association were elected. In spite of much wholehearted support given to the idea, the execution of a working program for the Association has developed slowly.

Of the concrete steps taken by the Association to develop a program of care for crippled children, those which follow are noteworthy:

1. A partial survey conducted for the purpose of locating crippled children in the greatest need of assistance was made;
2. A program of social work was set up, in which workers in the field of social readjustment of crippled children visited homes, and sent children to treatment centers and, where possible, to regular schools;
3. An educational program in the press which sought to explain the aims of the Association was started;
4. A series of representations addressed to the government, calling attention to the needs of crippled children and asking for cooperation, were made.

At the beginning of 1952, the Association already had 500 contributing members and was able to open its first school for crippled children. This school is in a rented house, but it is a residential school and takes care of thirty girls between five and fourteen years of age. At present the Association is raising funds to build a completely equipped modern school and rehabilitation center; this model school will be able to serve 160 crippled children.

The United Nations has supplied the Association with a technician in crippled children's education, Miss Celestine Igoe, former director of the Spalding School in Chicago. She has been a great help in organizing the school and is director of the school until such time as the Association is able to set up a local staff.

The Association is affiliated with the International Society for the Welfare of Cripples; from them, as well as from the National Society for Crippled Children and Adults and many interested North American orthopaedic surgeons, it has received great help and encouragement.

Book Reviews

TUBERCULOSIS OF BONE AND JOINT. Ed. 2. G. R. Girdlestone and E. W. Somerville, M.B., F.R.C.S (Edin.). London, Oxford University Press, 45 shillings; New York, Oxford University Press, 1952. $8.75.

The second edition of *Tuberculosis of Bone and Joint* has been expanded considerably as a result of the authors' increasing experience during the last eleven years. The section on pathology has been enlarged and embellished with photomicrographs. The appendix has been quite extensively revised. In addition, there is a brief discussion of the chemotherapy of tuberculosis. The authors, however, have avoided writing in detail of this, taking the stand that it is too early to evaluate results. They stress that, since no drug is available which will destroy all tubercle bacilli, the "bedrock" of therapy rests upon well established conservative and surgical methods. Theirs is an extensive experience, and the book represents the fruition, in a large measure, of the late Prof. Girdlestone's lifetime of thought and experience.

The early chapters deal with the pathology, diagnosis, and general treatment of bone and joint tuberculosis. There follow discussions of individual joints. Pertinent details concerning the pathology, differential diagnosis, and treatment, both operative and conservative, are well covered. Results from the authors' own series of patients are summarized at the end of each section. The appendix gives at considerable length technical details of the various devices used by the authors for immobilization.

The book presents an excellent philosophy for the treatment of bone and joint tuberculosis, emphasizes the systemic nature of the disease, and correlates the pathological changes with therapeutic procedures. The section on Pott's paraplegia is particularly noteworthy.

To some readers, at least, some of the statements and recommendations may seem out of date. For example, the use of lipiodol for myelography has in the United States been superseded by the use of safer media. Furthermore, no mention is made of removing lipiodol at the conclusion of the procedure.

The statement that sacro-iliac strain or subluxation is a "common condition" which must be differentiated from sacro-iliac tuberculosis will not go unchallenged.

The intentional omission of any detailed discussion of chemotherapy seems rather unfortunate, particularly in the discussion of the care and prevention of sinus formation. Chemotherapy certainly has modified present-day views concerning this complication.

To most American readers, the authors will seem unduly conservative, particularly in the treatment of spine tuberculosis. They defer spine fusion for prolonged periods, and in children conservative treatment is continued almost indefinitely. A back brace is recommended throughout the growth period. This seems hardly justified in view of the recorded good results with relatively early fusion. In this connection it is of interest that the last case report in the book concerns a woman, fifty-eight years old, with advanced pulmonary and spinal disease. Although her prognosis was considered poor, she could not be made comfortable in a plaster bed or a spinal frame and, finally, rather reluctantly, a spine fusion was carried out with an excellent result. Although, as the authors state, "this must not be regarded as a standard result", it would seem to lend some support to the more radical approach current on this side of the Atlantic. Be that as it may, the book is excellent and should be read by all who are concerned with this disease.

MANUAL OF ORTHOPAEDIC SURGERY. Committee on Undergraduate Training of The American Orthopaedic Association in collaboration with the Committee on Undergraduate Teaching of The American Academy of Orthopaedic Surgeons. Chicago, Central Office of Orthopaedic Surgery (122 South Michigan Avenue), 1952. $1.00.

There has long been need of a handbook for the use of undergraduate students of medicine when they begin their work of history-taking and examination on the orthopaedic wards and to serve as a guide for undergraduates, interns, residents, and instructors in the acquisition of knowledge of the fundamentals of applied anatomy, physiology, and chemistry, as these bear on orthopaedic diagnosis and outlines of treatment. These needs are simply and adequately met in the first forty-eight pages of the Manual. The remaining twenty-four pages contain tabulations of the criteria for bone-age determination and skeletal ossification, growth measurement charts, brachial and lumbosacral plexus outlines, classifications of tumors, an interpretation of bone lesions, a carefully selected list of reference books and periodicals of special orthopaedic interest, and, finally, the requirements for certification by The American Board of Orthopaedic Surgery for 1952.

The Manual is indispensable for those in each category—the undergraduate, the intern and resident, and the instructor.

It is extremely well done—a credit to the Committee on Undergraduate Training of The American Orthopaedic Association in collaboration with the Committee on Undergraduate Teaching of The American Academy of Orthopaedic Surgeons. The Manual was made possible by the John R. Thompson Fund.

Biologie, Pathologie und Therapie der Gelenke, dargestellt am Kniegelenk. Dr. med. et phil. Arnold Sonnenschein. Basel, Benno Schwabe & Co., 1952. Fr. 52.

The development of the knee joint in vertebrates is followed through the transition from fins to legs. Comparisons of the joint in the frog, lizard, mole, rat, bat, chicken, dog, and ape precede a detailed exposition of the development of the human knee. Gross and microscopic anatomy are given in a scholarly fashion. The mechanics is explained by means of diagrams and drawings.

The examination of an abnormal knee is outlined with encyclopedic thoroughness: history, inspection, palpation, passive and active movements, auscultation, examination of the blood, and exhaustive laboratory procedures. The technique of roentgenographic examination is given with a few illustrations from diagnostic films. Endoscopy and biopsy are discussed briefly.

Congenital malformations are listed for each individual structure of the knee and then for the knee as a whole. In the same manner, the acquired deformities and disabilities are presented. Without cumbersome detail, the treatment for each deformity is outlined.

The chapter on injuries of the knee is academic rather than practical. Emphasis is on conservative treatment. The author's mention of excision of the patella for comminuted fracture is so casual that one questions if he has had personal experience with the method. The principles of the treatment of fractures of the condyles of the femur and tibia are sound.

The differential diagnosis of diseases of the knee joint is outlined in great detail. Particularly good are the sections on the rarer lesions. The discussion on tuberculosis of the knee brings the subject up to date.

This book is a marvel of encyclopedic detail with particular value in differential diagnosis. The orthopaedic surgeon will need to supplement the text by further reading in operative orthopaedics and fracture management. With almost 500 pages and 219 illustrations, it is a valuable reference work for the student or general physician. The tone, however, is that of the classroom rather than of the busy hospital ward.

First Annual Report on Stress. Hans Selye, M.D., Ph.D. (Prague), D. Sc. (McGill), F.R.S. (Canada). Montreal, Acta, Inc., 1951. $10.00.

The technique of presentation of the subject matter conforms in every detail to that used in the original publication[1]. In this report may be found mention of investigative work in many fields which relate to the general adaptation syndrome—work which has been carried out since the publication of *Stress*. Deserving special mention is the newly accumulated information concerning the somato-trophic hormone (STH); it is too bad that there is no one chapter devoted to this new and important investigation for the reader must consult all entries of STH in the index to get at this newer knowledge. More easily approached is the excellent chapter on rheumatoid arthritis, which has been expanded from that in the original summary in *Stress;* it is discussed under such headings as clinical data, pathological anatomy, and therapy. After reading this section one feels that the author has made a good case for stating that this disease represents a general metabolic disorder and not a manifestation of joint pathology *per se*.

Of no small value is the bibliography of 134 pages placed at the end of the text and printed on buff-colored paper. References are complete and should prove of inestimable value to those wishing to consult the original contributions.

The book is hardly one to be read from cover to cover unless one's special field of interest is the study of "stress". It does offer, however, an extensive covering of research in the many fields relating to the reaction of the organism to disease processes and should, therefore, be of interest both to the academically minded and the clinician.

[1] The Physiology and Pathology of Exposure to Stress. Hans Selye, Montreal, Acta, Inc., 1950. Reviewed in *The Journal of Bone and Joint Surgery*, **33-A:** 818–819, July 1951.

Congenital Dysplasia of the Hip Joint and Sequelae (In the Newborn and Early Postnatal Life). Vernon L. Hart, M.D., F.A.C.S. Springfield, Illinois, Charles C. Thomas, 1952. $5.00.

This book covers in detail all phases of the dysplastic hip. It gives an excellent historical discussion of the over-all problem of congenital dislocation of the hip and includes a complete bibliography. The author assumes that all phases and degrees of congenital dislocation of the hip are preceded by and result from the simpler abnormalities which accompany "congenital dysplasia". Complete proof for this is, of course, lacking; and it could hardly account for the occasional infant in whom an otherwise uncomplicated complete dislocation of the hip is found prior to the age of six months. He also assumes that simple abduction treatment with a Frejka splint will suffice for any of these developmental defects before the age of six months or perhaps prior to walking age. This is not always true in a child with a marked subluxation or a complete dislocation—other means may be required.

The author reports one case of spontaneous healing of congenital dysplasia which he obtained from another orthopaedist. He states that this is the only such case he has seen. Many orthopaedic surgeons have seen one or more similar patients, and it raises the question as to how many of these milder developmental defects can and do heal spontaneously without treatment. The treatment used, however, is so conservative that no argument opposing such therapy can be considered valid in the presence of any manifestation of congenital dysplasia in the newborn child.

This book will serve its greatest purpose in stressing the importance of early diagnosis of this condition. If it will help to stimulate the routine examination of all newborn infants, the book will help to avoid the difficulties which are encountered with treatment in the older age groups. The book, therefore, should be studied by obstetricians, pediatricians, orthopaedists, and general practitioners—by all who may be concerned with the skeletal examination of the newborn.

MANUAL OF UPPER EXTREMITY PROSTHETICS. By the Staff, Artificial Limbs Project, Department of Engineering, University of California, Los Angeles, California. Edited by R. Deane Aylesworth. Los Angeles, University of California, 1952. $2.00.

This manual* has been prepared by the Staff of the Artificial Limbs Project under the guidance of the Advisory Committee on Artificial Limbs of the National Research Council and has been supported by contract with the Veterans Administration. It is the result of research and experience gained since World War II. It presents a practical guide to assist doctors, prosthetists, physical therapists, and all others concerned with rehabilitation of arm amputees in the selection, fabrication, and fitting of a suitable prosthesis.

In considerable detail the book describes the pertinent biomechanics of the upper extremity, the medical and hygienic considerations relative to amputation stumps, the technique of prescribing a prosthesis, and the commonly used wrist and terminal devices. The fabrication of the various types of prostheses is described in a step-by-step manner in great detail. Finally there are two sections dealing with physical therapy and amputee training and the materials and equipment needed by the prosthetist.

For the most part, emphasis is placed on the practical details of constructing and fitting, while theoretical considerations are omitted. For this reason the book will prove to be of greater value to limb fitters than to the surgeon who is faced with the occasional problem of prescribing a limb. The surgeon will find himself rather lost in the technical details of construction and will find only brief comment as to what type of limb, terminal device, or control system is most likely to suit his patient. Nonetheless, there is much practical information as to minimum requirements of motion in the elbow and shoulder, adjustment of the brace, training of the amputee, and the like, which are of great importance to the doctor.

The manual is well illustrated with black-and-white diagrams and photographs. It is by all odds the most authoritative and up-to-date book on the subject. It should be carefully studied by all who are concerned with the rehabilitation of the amputee.

PICTORIAL HANDBOOK OF FRACTURE TREATMENT. Ed. 3. Edward L. Compere, M.D., F.A.C.S., and Sam W. Banks, M.D., F.A.C.S., Revised with the Assistance of Clinton L. Compere, M.D., F.A.C.S. Chicago, The Year Book Publishers, Inc., 1952. $6.50.

In the Third Edition, the authors have brought the text up to date with added illustrations, including roentgenograms and line drawings, of new techniques. The chapters on Fracture Pathology, Aseptic Necrosis of Bone, and The Hip have been rewritten, while many changes have been made elsewhere.

This little book of 393 text pages is written for medical students and physicians in general practice, with the purpose of presenting clearly and concisely the basic principles and methods of treatment which the authors have found satisfactory in their own practice. On the whole, the book achieves its purpose in a highly commendable fashion. Sound principles and techniques are presented briefly and clearly without the confusion which results from reference to many different techniques. Sufficient details are given for the most part so that the reader can learn how to perform the manipulations and other techniques recommended. Caution is advised, however, in the use of those procedures for which specialized training is necessary.

Several minor points are open to criticism. Fracture healing is described in six steps. The third is "the deposition of calcium in connective tissue" to form callus, while the fifth step is the "transition of callus into osteoid tissue and deposition of bone". Most pathologists would agree that osteoid tissue is present in both callus and bone and that the change from callus to bone is a process of remodeling rather than of a "transition of callus into osteoid tissue". On page 95, in the discussion of renal calculi as complications of fractures requiring long immobilization in bed, no mention is made of limiting the calcium intake as a prophylactic measure. In the discussion of the treatment of fractures of the phalanges and metacarpals, it would seem advisable to place more emphasis on the danger of rotational deformity and the resulting disability. In discussing the treatment of fractures of the spine, no mention is made of the need for preliminary treatment of the ileus before reduction is carried out. Finally, in the discussion of the treatment of fractures and dislocations of the cervical spine, it is recommended that the neck be held in hyperextension. For those who have been so unfortunate as to see quadriplegia result from allowing the neck to hyperextend in the treatment of these lesions, a few more words of warning about this complication would seem warranted.

That the book has no bibliography is proper in such a handbook; however, it would have been worth while to furnish a few references concerning the techniques mentioned, such as, that for brachial or cervical block, or the insertion of Crutchfield or other tongs for skull traction in the treatment of fracture-dislocations of the cervical spine. In spite of these criticisms, this is a most valuable book and should be read by all who are concerned with the treatment of fractures.

* The *Manual of Upper Extremity Prosthetics* can be obtained from the Orthopedic Appliance and Limb Manufacturers Association, 336 Washington Building, Washington 5, D.C.

MONOGRAPHS ON SURGERY, 1952. B. Noland Carter, M.D., Ph.D., Editor. Baltimore, The Williams and Wilkins Company, 1952. $12.50.

In *Monographs on Surgery, 1952,* the section devoted to orthopaedics, under the editorship of Dr. A. R. Shands, Jr., contains four articles of interest to orthopaedic surgeons.

The Internal Fixation of Fractures of the Shafts of Long Bones by G. W. N. Eggers. Dr. Eggers gives an interesting historical review, which is short and to the point. He then presents in considerable detail his ideas concerning the influence of the contact-compression factor on osteogenesis in surgical fractures. Dr. Eggers feels that he has presented experimental evidence to prove the contact-compression factor. A more impartial observer may have less specific conclusions. The photomicrographs are well chosen and are clear.

The principles involved in the general management of fractures are well covered and proper emphasis is placed upon the mobilization of the involved joints. Also emphasized is the fact that metal fixation does not take the place of bone healing. The article is well illustrated.

Intracapsular Fractures of the Femoral Neck by E. R. Schottstaedt, L. J. Larsen, and F. C. Bost. By way of introduction, a short historical review of the milestones and the personalities involved in the treatment of these fractures is presented. The authors continue with a thorough discussion of their plan of treatment; it is given in detail and is worth careful review.

The mechanism of the various types of intracapsular fractures is discussed. Early care, anaesthesia, technique of reduction, and details of surgical procedure are carefully described.

Primary osteotomy of the McMurray type, or one with slight variations, is proposed in the treatment of certain fractures. It is the reviewer's impression that there is more enthusiasm expressed for this type of treatment than is warranted. Such an osteotomy does produce "physiological" knee valgus—severe enough at times in certain cases to require another osteotomy done at a lower level.

An outline review of the surgical procedures available for the treatment of non-union is presented and discussed in some detail. The reasons for the choice of any one procedure over the others are fairly presented and reflect personal experience.

Aseptic necrosis, infections, and other complications are discussed briefly.

Fractures of the femoral neck in children are also discussed and four brief case reports, which are worthy of study, are presented.

Aseptic (Avascular) Necrosis of the Femoral Head in Adults by William Cooper. Dr. Cooper deals with this difficult problem in an orderly manner. Interference with the blood supply is presented as the common factor in all instances of aseptic, hence avascular, necrosis. The etiology is discussed under the headings of fractures, dislocations, caisson disease, Gaucher's disease, radiation, sickle-cell anaemia, and idiopathic forms of which the cause is less clearly defined.

Excellent pathological material is presented in the form of photographs of sections and correlating x-rays.

Treatment is discussed, and neurectomy, arthrodesis, arthroplasty, and replacement prostheses are fairly considered. An excellent list of references is furnished.

Arthroplasty by Robert A. Knight. The history of arthroplasty and the personalities responsible for its development are briefly reviewed.

A fairly didactic list of indications and contra-indications for arthroplasty is properly presented. The technique of arthroplasty in general is reviewed with attention to principles. The consideration of technique is divided into four parts: plastic adjustment of the soft tissues, reconstruction of the bone, interposition of metal or tissue between bone ends, and after-care.

Details of the technique for arthroplasty of the knee, the hip (the Smith-Petersen and Gibson approaches are described), temporomandibular, elbow, and metacarpophalangeal joints are discussed and illustrated.

Monographs on Surgery, 1952 belongs in the library of every orthopaedic surgeon.

ORTHOPAEDIC NURSING. Mary Powell, S.R.N., M.C.S.P., Orthopaedic Nursing Certificate. Edinburgh, E. & S. Livingstone Ltd., 25 shillings; Baltimore, The Williams and Wilkins Company, 1951. $5.50.

This worth-while text, which was written primarily for nurses and physical therapists working in orthopaedic hospitals and for nurses caring for orthopaedic patients in other hospitals and in sanatoria where bone and joint tuberculosis may accompany the pulmonary lesions, reflects the orthopaedic nursing experience at the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, England. It is apparent that the author is concerned with making the patient both happy and comfortable during treatment; the book is full of practical suggestions for accomplishing these goals.

After a brief introduction, the author begins with a discussion of the relationship of physical therapy to orthopaedics; she continues with a treatment of plaster-of-Paris technique, splints, and other appliances. The body of the work is devoted to the care of the patient with congenital deformities, deformities of the spine, legs, and feet. Over 100 pages are devoted to tuberculosis, in contrast with eleven pages for poliomyelitis and eight pages for cerebral palsy.

The work is brought to a close with an excellent chapter dealing with the social aspect of after-care by Mona Williams.

Mezzi della Moderna Osteosintesi in Traumatologia. (Relazione al XXXVI Congresso della Società Italiana di Ortopedia e Traumatologia, Roma, 20–22 ottobre 1951.) Relatore: Prof. Carlo Marino-Zuco. Roma, 1951.

The book is a voluminous compendium of the work done in the past decades relating to osteosynthesis. A good portion of Part I is devoted to a review of technical methods, which are well illustrated. Included are observations on the use of bank bone and a short report on histological studies of regeneration and revitalization of the transplant. After some mention has been made of the use of organic non-osseous substances in transplantation, the subject of inorganic metallic substances used for osteosynthesis is discussed at length.

The technical part includes a description of scales, traction tables, and various other instruments, some of which bear the names of the authors. The question of allergic reaction, which is very ably handled, is then entered into for all types of metal, including, of course, Vitallium and stainless steel. The information is based mainly on what has been reported in the literature and on some of the authors' own findings. This is followed by a section dealing with the various techniques of osteosynthesis, the principal subject of the work. All types of fixation from wires, metallic bands, and screws to nails, plates, and staples are minutely described and the manner of their application is discussed in detail. The Küntscher nail is given proper attention and its success is particularly well demonstrated by case reports. Interesting also is the use of the "half pin" which is credited to Lambotte (1927), whereas we credit it usually to Roger Anderson (1936) and to Stader. What engages the attention of the reader most is the authors' individual experiences in osteosynthesis. This is very well documented by abundant material taken from the Clinic on Orthopaedic Surgery and Traumatology of the University of Rome. This wealth of material is divided into groups with special indications given for the young and the aged, for open fractures, for delayed union, for pseudarthrosis, and particularly for pathological fractures (including those caused by osteomyelitis).

Part II constitutes the essential section of the work because it deals systematically with the locations of fracture; the documentation with personal cases provided by the Clinic is abundant. The first chapter deals with articular and periarticular fractures and fracture-dislocations of the humerus, elbow, radius, hip, knee, and ankle; cases are presented which had been treated with nailing, screws, wire loops (for patellar fractures), plates, and Jewett and Neufeld blade plates, with technical details presented in diagrams.

The next chapter of this section is devoted to the diaphyseal fractures of the leg, including transplantations for tibial pseudarthrosis and the Harrington technique of implanting the fibula into the tibia (reported by Putti in his paper *Perone pro tibia*). The authors then proceed to deal with fractures of the femur, treated with plating, wiring, and the Küntscher nail. Particularly interesting are cases of fractures of both forearm bones treated with Kirschner wires. Finally fractures of the humerus are discussed.

Chapter III of this part is devoted to the osteosynthesis of the shoulder girdle, including treatment of such conditions as fracture of the neck of the scapula, acromioclavicular dislocation, fracture of the clavicle, and sternoclavicular dislocation. The methods used are again largely the conventional ones, although the usual attention is again given to various modifications which are diagrammatically illustrated.

Fractures of the spine (Chapter IV) are treated more perfunctorily, although all sorts of methods of spinal osteosynthesis are presented, including the H graft.

The next chapter deals with fractures of the scaphoid and metatarsals, with bare mention of fractures of the os calcis and of the pelvis.

Part III is largely statistical. In its first chapter there is a valuable section dealing with the general indications for osteosynthesis in the various portions of the skeleton, although no particular distinction is made in regard to specific methods.

The final chapter of the work is more decisive and gives end results and disability percentages for all of the bones of the body in figures which seem acceptable and conservative. A most imposing bibliography is appended to the work.

This most carefully prepared book from the hands of Prof. Carlo Marino-Zuco and his many collaborators, Dr. Vincenzo Pietrogrande, Dr. Niccolò Pancino, Dr. Attilio Rampoldi, Dr. Manfredo Ascoli, and Dr. Ettore Tranquilli-Leali, is the report given by these men before the Thirty-sixth Congress of the Italian Society of Orthopedic Surgery and Traumatology. No doubt it is most up-to-date. It takes into consideration all methods of bone reconstruction up to the present time.

Its casuistic sections are founded on over 1,100 cases from the authors' own experiences. If any criticism can be made, it is of the great multiplicity of the methods described and, although indications are stated in a general way, the reader is left, perhaps, in doubt regarding the selection of methods. The book is excellently written and represents a valuable source of information on the subject of osteosynthesis.

Medizinische Röntgentechnik. Lehrbuch für medizinische-technische Assistentinnen, Studierende und Ärzte. II. Teil. Physikalisch-technischer Teil: 1. Grundlagen der Strahlendiagnostik und Strahlentherapie, Apparatekunde; 2. Röntgen- und Farbenphotographie. Prof. Dr. H. Schoen. Stuttgart, Georg Thieme Verlag, 1952. DM 27.

The second volume of *Medical Roentgen Techniques* by Schoen presents a rather unusual and interesting approach to many problems not ordinarily found in the average textbook.

The book is divided into two major parts. The first section deals with the physical and technical fundamentals of radiation diagnosis and therapy, including certain data pertaining to x-ray apparatus; the second takes up problems incidental to radiation and color photography.

In Section I, it is rather amazing but pleasing to find technical matters described in so simple a manner that it is easily comprehensible even to those not conversant with the physical background of the problem. Nevertheless, the scope of these chapters is considerably beyond that which is usually offered the average technician and will prove of particular value for those teaching and supervising student technicians. It will be fruitful reading also for those whose special interest is focused on one or any of the subjects discussed in detail. Such problems include the basic physics of electricity, the atom, the nature and physical properties of x-rays, the manner of generation and the application of x-rays in diagnosis and treatment, the determination of dosage, and the means of affording protection from x-rays.

The second part of the book describes many valuable technical matters. The photographic aspect of roentgenographic technique is explicitly presented; the technical, physical, and chemical requirements in the handling of films before and after exposure are described. One of the most worth-while chapters has to do with artefacts so often found on the roentgenogram, their interpretation and the means of preventing their occurrence.

A chapter on color photography and another on the photographic and chemical aspects of technique conclude this excellent book.

Schoen's *Medical Roentgen Techniques*, though beyond the needs of the average technician, will be helpful to those instructing technicians and to those whose work requires knowledge of the specially developed features of radiological technique.

LUMBAR DISC LESIONS. Pathogenesis and Treatment of Low Back Pain and Sciatica. J. R. Armstrong, M.D., M.Ch., F.R.C.S. Edinburgh, E. & S. Livingstone Ltd., 42 shillings; Baltimore, The Williams and Wilkins Co., 1952. $8.00.

This is a comprehensive monograph based on an exhaustive review of the literature and the author's very considerable clinical experience. The embryology, anatomy, and pathology of the lumbosacral spine are considered in detail. This consideration is followed by a careful exposition of the pathogenesis of back pain and sciatica resulting from disc lesions, which is beautifully illustrated with diagrams. While the critical reader at times may feel that a clear distinction between theory and fact is not always made, there is, on the whole, an excellent review of prevailing opinion.

The differential diagnosis of back pain and sciatica is dealt with at great length and with considerable clarity. However, as is virtually inevitable, the reader soon realizes that the signs and symptoms of many back conditions are so similar that accurate diagnosis is not so simple as the text would seem to indicate. The conservative and operative treatment of disc lesions, as well as the management of recurrent or unilateral pain following operation, is well described. There are excellent colored reproductions of operative findings. The author emphasizes the mechanical derangement which occurs after surgical removal of the disc; he stresses the importance of fusion, when this is indicated, and the prolonged protection of the back, when fusion is not performed, to permit the formation of fibrous ankylosis. Many will not agree, perhaps, with his statements concerning myelography and the need for such prolonged immobilization in recumbency after spine fusions.

Although the literature is fully covered for the most part, the author does not refer to the work of Swedish orthopaedic surgeons on disc degeneration, roentgenographic demonstration of instability, and disc puncture. In such a monograph, this important work would seem to have a place.

The book, nonetheless, is excellent, and it is recommended highly to all surgeons concerned with the problem of back pain and sciatica.

SURGICAL FORUM. Proceedings of the Forum Sessions; Thirty-seventh Clinical Congress of the American College of Surgeons, San Francisco, California, November 1951. Philadelphia, W. B. Saunders Company, 1952. $10.00.

This volume contains the papers presented at the Surgical Forum meetings of the Thirty-seventh Clinical Congress of the American College of Surgeons in San Francisco. Like the previous volume, it is a compilation of brief presentations concerning almost every surgical specialty. The majority of papers deal with fundamental research and are presented in full or, in a few instances, in abstract. The book thus summarizes surgical research of the previous year. It is of considerable interest to orthopaedic surgeons not only because of the papers dealing with orthopaedics, but also because it offers a summary of work in other fields of surgery. Some of the fundamental research in other specialties shows promise of being applicable to orthopaedics.

In many ways the volume is ideal for the busy orthopaedic surgeon who finds little time to keep up with the recent advances in other fields of surgical endeavor.

Transactions of the American Orthopaedic Association

Volume I of *The Journal* (then called the *American Journal of Orthopedic Surgery*), published in 1903, took the place of Volume XVI of the Transactions of the American Orthopaedic Association. From time to time *The Journal* has requests for copies of the volumes issued prior to that date. Any reader having copies of these earlier volumes, which he is willing to dispose of, is requested to write to *The Journal*, indicating volumes available and selling price.

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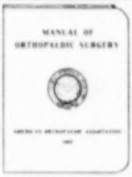

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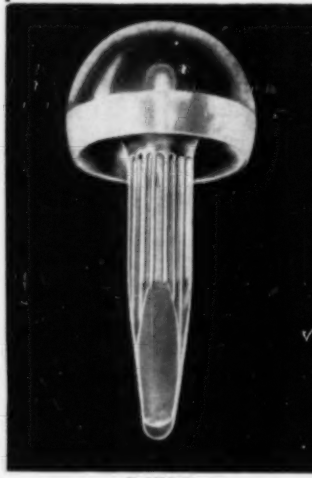

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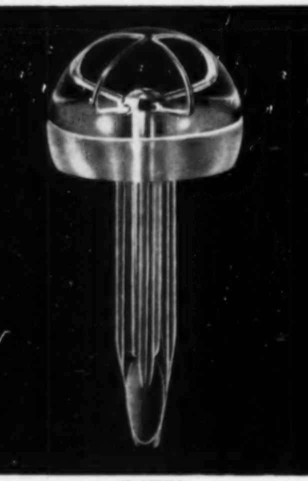

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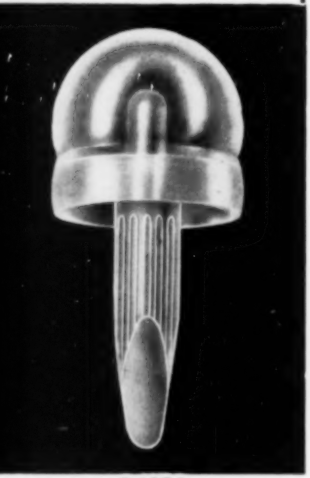

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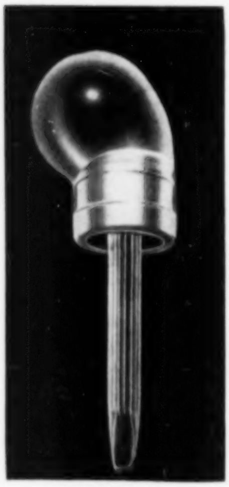

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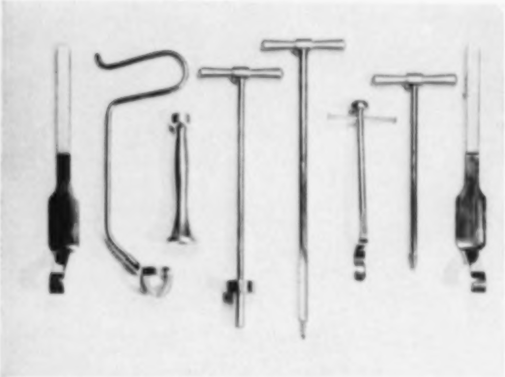

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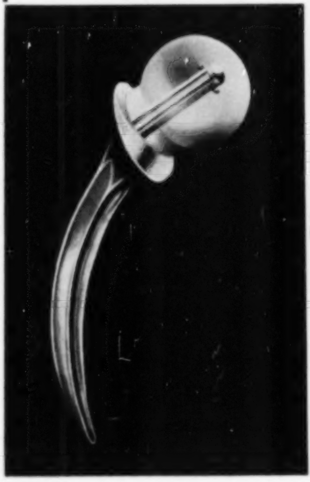

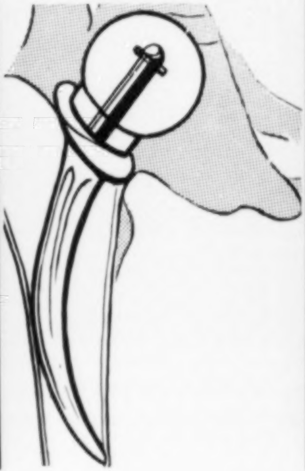

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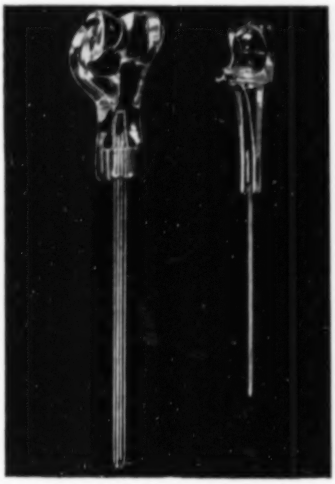

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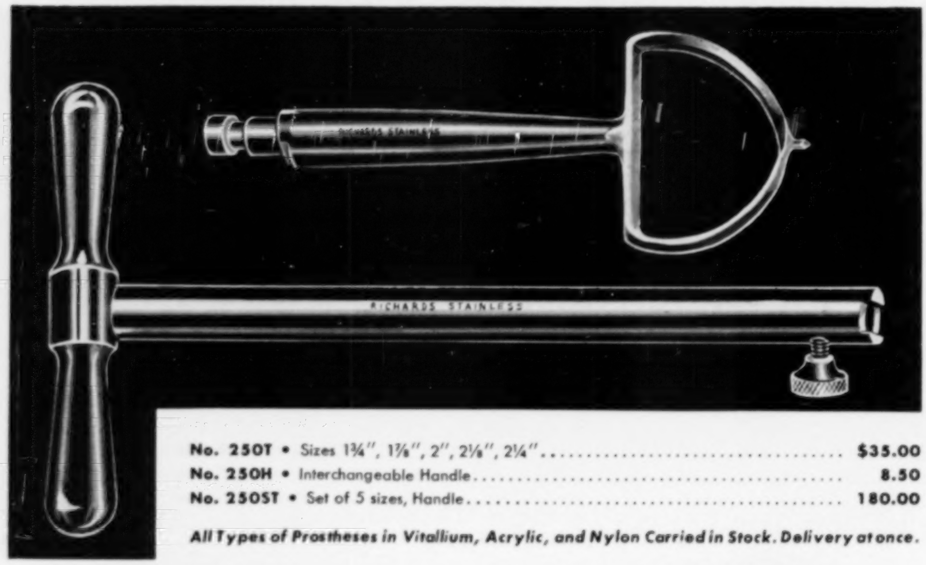

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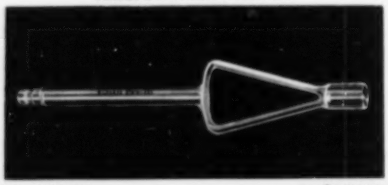

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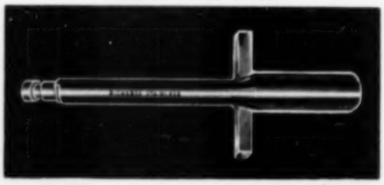

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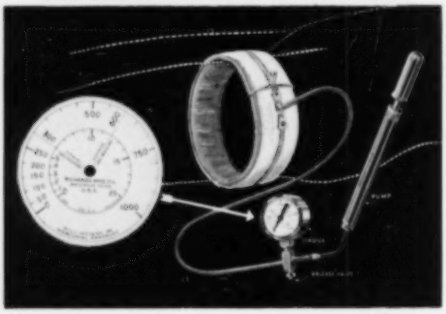

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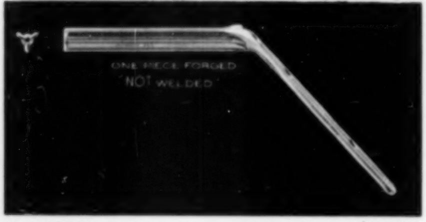

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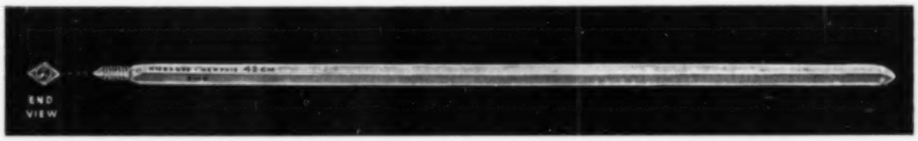

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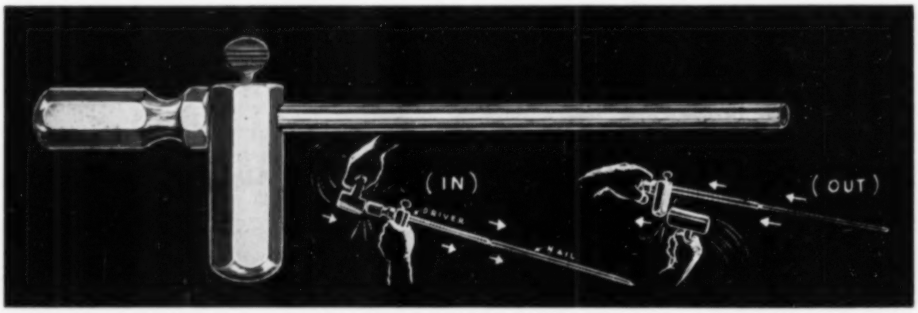

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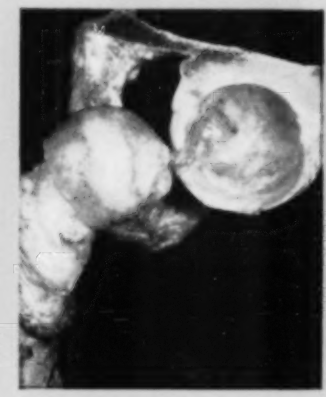

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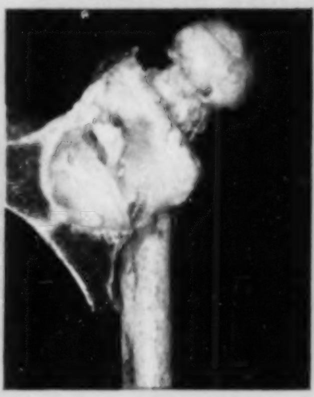
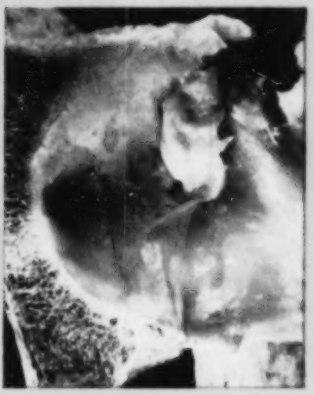
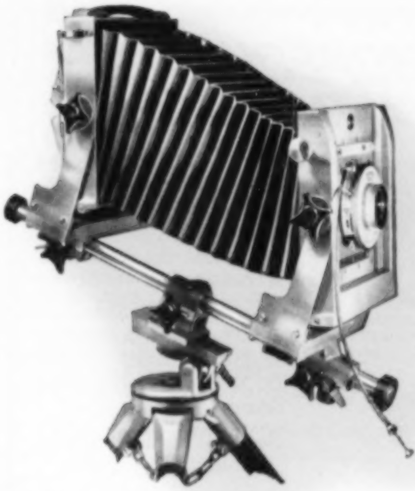


Degenerative change of femur and acetabulum



Close-up shows changes of acetabulum and joint body



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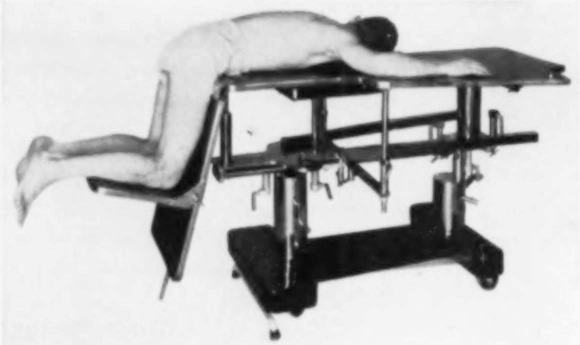

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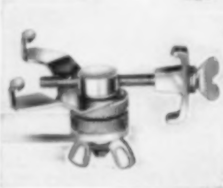

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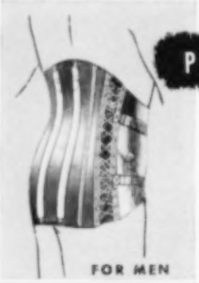

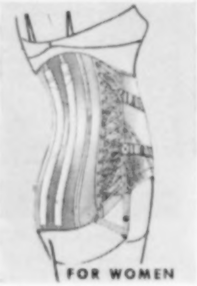

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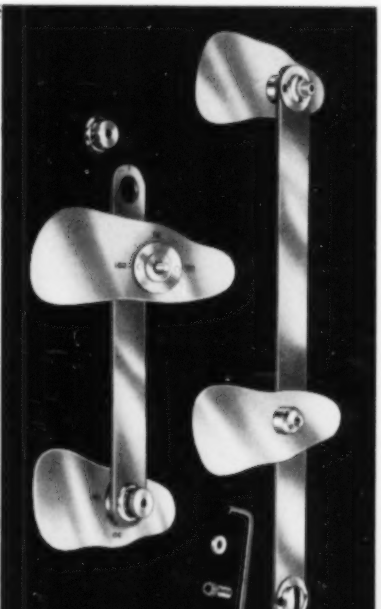

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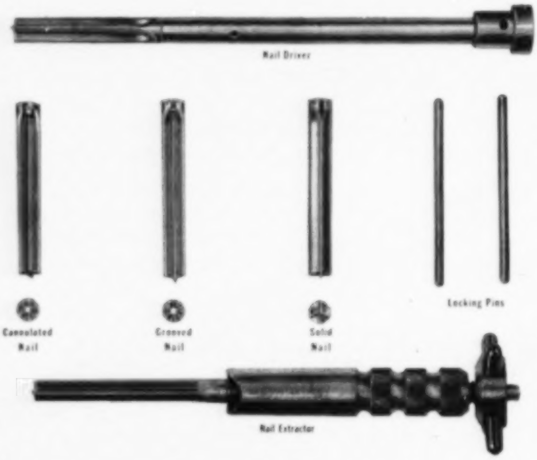

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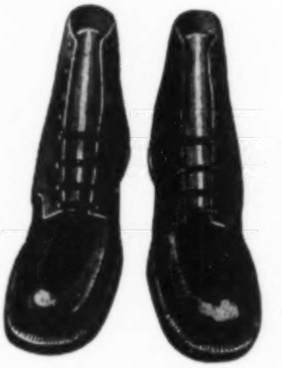

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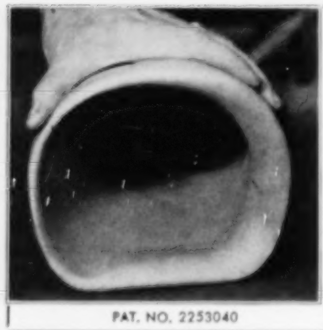

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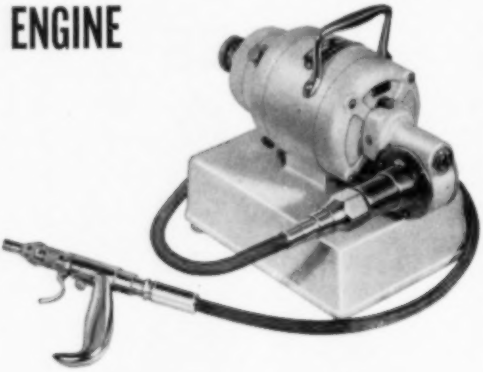

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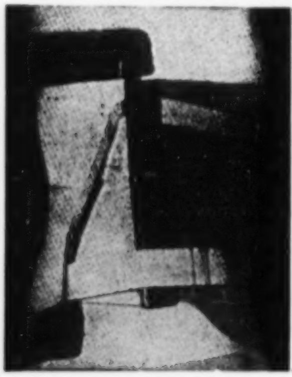

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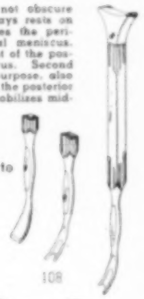

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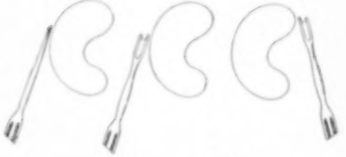

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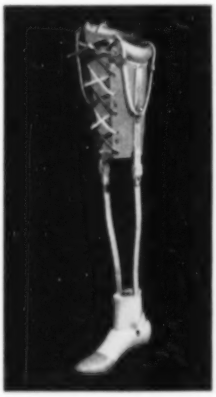

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